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V

PROCEEDINGS

OF THE

ASSOCIATION OF MUNICIPAL AND SANITARY ENGINEERS AND SURVEYORS.

VOLUME V.—1878-9.

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EDITED BY
CHARLES JONES,
ASSOC. INST. C.E.,
HON. GENERAL SECRETARY OF THE ASSOCIATION.

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PREFACE.

In perusing the Papers gathered together in the accompanying volume, we feel assured that our fellow Members will realise more than ever the value of the "Association" from which they have emanated and the importance of binding its Members more firmly together, and at the same time of exerting themselves in the effort to enroll amongst their number the many officers of Urban Districts not associated with them. The subjects treated of concern every Borough Engineer and Local Surveyor in the Kingdom, and are the results of personal experience. Taking into consideration the rapid progress of Sanitary Science, and the efforts that are being made on every hand to impress upon the minds of the present and rising generation the importance of an acquaintance not only with its first principles, but also its more advanced and elaborate theories, we are sure that our readers will be encouraged by the thought that we are doing our part as an "Association" in the great work of Sanitary improvement, and will be incited to fresh exertions in the accumulation of knowledge which may be disseminated amongst their brother officers, not only in their various District Meetings, but through the pages of future volumes of their "Proceedings," and thus add to the general fund of information bearing upon the many important questions to which their attention in an official capacity is daily directed.

C. J.

Local Board Office, Ealing, W.

27358

CONTENTS.

PAGE

Preface iii

List of Officers vii

List of Members viii

List of Towns xiii

Rules xvii

Cash Statement xix

Annual General Meeting, Liverpool—

General Business 1

President's Address: G. F. Deacon 14

Notes as to Certain Municipal Works in Liverpool, by G. F. Deacon 22

Letter from Mr. Lyster, Engineer to the Mersey Docks and Harbour Board 45

Discussion 47

The Annual Dinner 60

Court and Cellar Dwellings in Liverpool, by J. Stopford Taylor, M.D., Medical Officer of Health for the Borough of Liverpool .. 73

Discussion 81

The Geology of Liverpool in Relation to Engineering Work, by T. Mellard Reade 90

Discussion 98

On the Manufacture of Manure from Town Refuse, by T. Hewson 104

Discussion 110

Further Remarks on the Ventilation of Sewers, by E. B. Ellice-Clark 116

Discussion 127

Suburban House Drainage and Water Supply, by Robert Vawser .. 141

District Meetings—

PAGE
Meeting at Derby 145
Remarks on the Programme of the Sanitary Institute of Great Britain, by E. B. Ellice-Clark 146
Meeting at Wrexham 151
Pneumatic Sewage System, by Isaac Shone, Mayor of Wrexham .. 152
Colonel Jones's Sewage Farm 161
Discussion.. 165

ASSOCIATION OF MUNICIPAL AND SANITARY ENGINEERS AND SURVEYORS.

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I.—That the Society be named the "Association of Municipal and Sanitary Engineers and Surveyors."

II.—That the objects of the Association be—

a. The promotion and interchange among its Members of that species of knowledge and practice which falls within the department of an Engineer or Surveyor engaged in the discharge of the duties imposed by the Public Health, Local Government, and other Sanitary Acts.

b. The promotion of the professional interests of the Members.

c. The general promotion of the objects of Sanitary Science.

III.—That the Association consist of Civil Engineers and Surveyors holding permanent appointments under the various Municipal and Sanitary Authorities within the control of the Local Government Board, and such Honorary Members as shall be elected by the Council. Members who retire from their official position are eligible for re-election by the Council.

IV.—That the Affairs of the Association be governed by a Council, consisting of a President, Three Vice-Presidents, Twelve Members, and a Honorary Secretary, to be elected annually. The Past Presidents and the District Secretaries for the time being shall also be Members of the Council.

V.—That the Council shall nominate one name for President, six for Vice-Presidents, one for Secretary, and twenty-two Ordinary Members from whom to elect the Council. Such Nominations shall be printed and sent to each Member of the Association not less than thirty days previous to the Annual Meeting. Every Member shall be entitled to vote for or erase any of such Nominations, or substitute other names, subject in all cases to the limits of Rule IV., and return the same within seven days of the date of issue, and the Members who shall obtain a majority of votes shall respectively be duly elected President, Vice-Presidents, Members of Council, and Honorary Secretary for the ensuing year.

VI.—That the Association be formed into District Committees which shall include the whole of the Members. Such Committees shall meet from time to time, in convenient centres, for the discussion of matters of local and general interest connected with the Association. Each District Committee shall appoint a Local Secretary, who will keep records of local proceedings, and communicate with the Council. No District Committee or Local Secretary shall be entitled either to represent or act on behalf of the Association.

VII.—That a General Meeting and Conference of the Association shall be held annually in such towns, in rotation, as may afford convenient centres for assembling the Members.

VIII.—That an entrance-fee of One Guinea, and a subscription of One Guinea per annum, from Civil Engineers and Surveyors under Rule III., shall constitute Membership of the Association.

SUBSCRIPTION ACCOUNT.

	£	s.	d.		£	s.	d.
Arrears from last year	109	4	0	Received for Arrears	42	0	0
Subscriptions due for current year	177	9	0	„ Subscriptions	117	12	0
Admission Fees	7	7	0	„ Admission Fees	7	7	0
				Error in Subscription Account	8	8	0
				Balance—Arrears due	118	13	0
	£294	0	0		£294	0	0

CASH ACCOUNT.

Receipts.	£	s.	d.	Expenditure.	£	s.	d.
Arrear Subscriptions	42	0	0	Balance from last year	4	8	0
Current „	117	12	0	Home Counties District	23	10	0
Admission Fees	7	7	0	Midland Counties District	4	11	0
Sale of Proceedings	34	2	5	General Expenses—			
				Printing Proceedings	28	5	6
				Printing and Stationery	7	1	6
				Advertisements	1	2	0
				Expenses at Bristol Meeting	46	14	3
				Stamps	4	15	4
				Expenses at Council Meetings, 1875–6–7	7	7	0
				Secretarial Expenses	10	10	0
				Petty Cash Sundries	6	0	0
				Error in Subscription Account	8	8	0
				Balance carried forward	48	8	10
	£201	1	5		£201	1	5

I have examined the above Accounts and compared them with the vouchers and receipts, and certify them to be correct, and that the amount in hand at the close of the Subscription year 1878 is £48 8*s.* 10*d.*, and that the amount of arrears due is £118 13*s.*

July, 1879.

(Signed) Albert W. Parry, *Auditor.*

ADVERTISEMENT.

The Association is not responsible for the statements or opinions advanced in the Papers and Discussions contained in the following pages.

ASSOCIATION OF MUNICIPAL AND SANITARY ENGINEERS AND SURVEYORS.

FIFTH ANNUAL MEETING.

LIVERPOOL, *July* 25*th*, 26*th*, *and* 27*th*, 1878.

FIRST DAY'S PROCEEDINGS.

THE Members of the Association assembled at half-past twelve o'clock on Thursday, July 25th, in the Council Chamber, at the Town Hall.

Mr. F. ASHMEAD, M. Inst. C.E., of Bristol, President of the Association, occupied the chair.

The PRESIDENT said he was very much pleased to meet the Members once again, and to see so many present at the Annual Meeting, though he had hoped they would have had a much larger attendance. He had no doubt they would have a very pleasant meeting.

The PRESIDENT then called upon the Hon. Secretary, Mr. C. Jones, to read the Annual Report of the Council.

REPORT OF THE COUNCIL OF THE ASSOCIATION OF MUNICIPAL AND SANITARY ENGINEERS AND SURVEYORS, FOR THE YEAR 1877–8.

GENTLEMEN,—It is with much pleasure that your Council have again the opportunity of meeting the Members of the Association at this our Fifth Annual Meeting in this important town of Liverpool, and in referring in a few short statements to the business of the past year.

Since our meeting at Bristol last year, when our esteemed friend and coadjutor, Frederick Ashmead, Esq., was elected to fill the office of President, a considerable amount of increasing and important work has been done, the towns visited being Bristol, Bradford, Dartford, Exeter, Wolverhampton, and Southport; and as you have visited all or some of these places in connection with the Association, it is hardly necessary to say that the works inspected, the papers read, and the discussions which followed, have been productive of immense benefit to those of our Members who were able to attend, while at the same time the printed details of those visits will form a reference book to all, whether the places have been visited or not, for these papers must of necessity have an especial value to the members of our profession, being in the majority of cases the productions of those who have had the practical working out of the matter on which they have written, and not the mere visionary theories of men whose schemes, coloured up with all the glare of a hoped-for success, prove but of little value when brought to the test of practical and every-day work.

The question of printing Proceedings has occupied the attention of the Council, and although some difficulty arose in connection with the subject last year, it is hoped that the arrangement decided upon at a Council Meeting in the early part of the year, viz. to print the Proceedings in pamphlet form soon after the Meeting, has proved a success.

Three pamphlets have already been issued, two more are in hand, and the type having been in good part set up for the papers proposed to be read at this Meeting, the entire Proceedings for the year will be out within three months of the present time.

The Council desire very much to see an increase of the number of Members of the Association, as it is evident that very many to whom the information would be of the greatest value are from various circumstances unable to attend the Meetings. It has been suggested that probably some plan might be devised by which a larger number of Surveyors may be brought in as subscribers, and thus have the advantage of the publications, although unable to attend the Meetings.

Since the last Annual Meeting a new District, to be called the Western Counties and South Wales District, has been formed, with Mr. H. P. Boulnois, of Exeter, as Secretary, and the Council confidently look forward to a considerable increase of Members from this District.

In accordance with the Rule of the Association, the balloting lists were issued in June last, and the Council report the result as follows:—

President.—G. F. Deacon, M. Inst. C.E., Liverpool.

Past-Presidents.—Lewis Angell, M. Inst. C.E., London; J. G.

Lynde, M. Inst. C.E., Manchester; James Lemon, M. Inst. C.E., Southampton; F. Ashmead, M. Inst. C.E., Bristol.

Vice-Presidents.—A. M. Fowler, M. Inst. C.E., Newcastle-on-Tyne; A. W. Morant, M. Inst. C.E., Leeds; E. Pritchard, C.E., Warwick.

Ordinary Members of Council.—W. B. Bryan, Assoc. Inst. C.E., Blackburn; C. Dunscombe, M.A., Derby; S. Harpur, Assoc. Inst. C.E., Merthyr Tydfil; J. Lobley, Assoc. Inst. C.E., Hanley; P. C. Lockwood, M. Inst. C.E., Brighton; J. Proctor, M. Inst. C.E., Bolton; E. J. Purnell, C.E., Coventry; E. L. Stephens, C.E., Leicester; G. E. Thoms, Assoc. Inst. C.E., Wolverhampton; S. C. Thorburn, C.E., Birkenhead; C. Thwaites, M. Inst. C.E., Sunderland; W. S. Till, M. Inst. C.E., Birmingham.

Auditor.—A. W. Parry, Assoc. Inst. C.E., Reading.

District Honorary Secretaries.—E. B. Ellice-Clark, Assoc. Inst. C.E., Hove, Home Counties District; E. Pritchard, C.E., Warwick, Midland Counties District; B. C. Cross, C.E., Dewsbury, Yorkshire District; R. Vawser, M. Inst. C.E., 2, Cooper Street, Manchester, Lancashire and Cheshire District; H. P. Boulnois, M. Inst. C.E., Exeter, Western District.

General Honorary Secretary.—C. Jones, Assoc. Inst. C.E., Ealing, W.

The PRESIDENT said, Perhaps some Member would move the adoption of the Report, or make some remarks thereon.

Mr. PARRY (Reading) moved the adoption of the Report.

Mr. LOBLEY (Hanley), in seconding the motion, said he thought it was a very important matter that the Reports should be sent both to those who were present at the Meetings and also to those who were not able to attend them. Possibly there might be others who were in the same position as himself, and had not received the Reports, but that was the first time he had heard that three had been issued. He had only received one three days ago, and that was of the Wolverhampton Meeting. He suggested, at the Wolverhampton Meeting, and the suggestion seemed to meet with approval, that a select copy should be kept in the hands of the printer for any Member who desired it for binding like the previous annual volumes, even if a small increase of subscription were necessary, but no resolution was come to. The Reports of the Meetings, being sent separately, were apt to get soiled, and of course they came through the post folded, and it would not be so satisfactory to Members to have these as it would be to have an annual volume.

He thought, therefore, that for those who desired it some arrangement of the sort he had suggested should be made.

The PRESIDENT having asked Mr. Jones to state what the arrangements were—

Mr. C. JONES (Hon. Sec.) said that the Dartford pamphlet was issued within six weeks of the Meeting. That went out from his own office. The Proceedings at the Sheffield Meeting were published within about five weeks. They were sent out by Mr. Cross in mistake. There was a misunderstanding about it. The pamphlet should have been sent up to him (the Secretary), and have gone out in the ordinary way.

Several Members said they had not received it.

The HON. SECRETARY said the next pamphlet—the Wolverhampton pamphlet—was issued about a week since. That he sent out from his own office.

Several Members said they had not received it, and one Member said he had not received one of the three.

Mr. DEACON (Liverpool) suggested that those Members who had not received the pamphlets should leave their names with the Secretary, and then the matter could be inquired into. With reference to the future, some better plan should be adopted.

The HON. SECRETARY said that in the next pamphlet he would state what pamphlets had been already issued; and if Members who had not received all the numbers would be good enough to inform him, he thought there were sufficient copies on hand to supply them.

Mr. PRITCHARD (Vice-President) thought that the issuing of the Proceedings in pamphlet form after each Meeting was very unsatisfactory. He took it that their course had been discussed and decided upon by the Council, but it ought either to have the support of the General Meeting or be altered. He was strongly in favour of the Proceedings being issued in a volume; and if it was at all necessary that the Members should contribute a little extra in order to have the Proceedings in this form, he did not think for a moment there would be any objection to do so.

Mr. DEACON (Liverpool) said he was not present at the Council at which the matter was discussed. He would suggest that if on future occasions they were enabled to issue the papers in proof, as they had issued them on that particular occasion, it would be an incentive to gentlemen to come to the Meeting if only those who were about to come received those papers in proof; and he thought the others might wait for the Proceedings in the bound and complete form in which they would ultimately receive them. They did not want the discussions, as a rule, in pamphlet form. He thought it would be quite sufficient to have the papers, and Members who did not attend the Meetings would have to wait for the discussions.

The PRESIDENT said he quite agreed with the suggestion, and it was quite open to any Member to make such a proposition.

Mr. DEACON said that to the circulars sent out there were fifty-nine answers from gentlemen who said they were coming to that Meeting and would like to have the papers in proof; and he was quite sure that if these proofs could always be sent, their discussions would be very much better than they could possibly be if Members had to discuss papers after merely listening to them.

The HON. SECRETARY said there was a little extra expense, of course, attaching to it, but he thought something like 2*s.* 6*d.* would meet it. The setting up of the type in the first instance was the principal expense, and he did not suppose that an additional copy would cost more than 3*d.* or 4*d.*; so that for six or seven Meetings in the year the cost would not amount to more than 2*s.* each, and then there would be 6*d.* each for the extra postage.

Mr. DEACON: That is with reference to these proofs.

The HON. SECRETARY: Yes.

Mr. THORBURN (Birkenhead) thought that Mr. Deacon's suggestion to circulate the papers before the Meeting and print the discussions afterwards was a very good one. It had been tried in several other societies, and it had been found that instead of people stopping away from the Meetings through getting the papers beforehand, it induced them to take an interest in the discussions, and they came better prepared to enter into them.

The HON. SECRETARY said he was glad to find that that which the Council were doing now was meeting the approval of the Members and was successful, but there was this difficulty about it, that it would throw a considerable amount of work upon the District Secretaries. They must obtain all the papers for their District Meetings, at least a fortnight or three weeks before the time of Meeting, though he believed they would get better Meetings in consequence.

Mr. THORBURN (Birkenhead): Better papers.

Mr. ELLICE-CLARK (Hove): What becomes of Mr. Lobley's suggestion that we should have the whole of the Proceedings in one volume and not after the Meetings?

The Hon. Secretary: You would get both.

The President: Just the same as the Members of the Institution of Civil Engineers do.

Mr. Thorburn proposed that in future the papers to be read at the District Meetings be printed beforehand, and that the District Secretaries ascertain by circular those Members who intend to attend the Meetings, and furnish them with copies of the papers.

Mr. Hall (Toxteth Park) seconded the proposition.

Mr. Parry (Reading) said the only alteration he would suggest in the proposition was, that copies of the papers should be sent to every Member, and not only to those who intended to attend the Meetings.

Mr. Thorburn had no objection if the funds were sufficient.

Mr. Parry said it was not a question of funds. He thought it was worth doing, and if the present funds were not sufficient let the subscription be increased.

Mr. Thorburn said they might charge sixpence a copy or something like that.

Mr. Deacon (Liverpool) asked, would it not be desirable to make it an incentive to Members to come to the Meetings by only issuing the papers to those who said they were going to attend. Those who were not going to attend could not care very much whether they got the Proceedings within a day or two, or in a month.

Mr. Parry: It is a question whether they shall get them within a year.

The Hon. Secretary: No; the resolution now is that the Proceedings shall be published shortly after the Meetings, in a pamphlet form.

Mr. Ellice-Clark (Hove): Mr. Lobley and Mr. Pritchard said they would prefer that the Proceedings should come out as previously in one volume. If they were to be sent out immediately after the Meetings, should they, in addition, under that resolution, send them out as an annual volume? That is what we want to decide to-day.

The Hon. Secretary said the intention of the Council was that the Proceedings should go out as soon as possible after each District Meeting, and that then the Secretary should communicate at the end of the year with each Member, stating that the pamphlets, if sent up to him, would be passed into the printer's hands and be bound. They could then be bound at a small charge—something like 8*d.*

Mr. DEACON: Or you might add that if any Member wished for an additional copy, it would be charged for at such and such a price.

The HON. SECRETARY: Then Members will take care of their copies and send them up.

Mr. THORBURN: Or get them bound themselves.

A MEMBER called attention to the fact that the resolution which had been moved, that the Report be adopted, had not yet been put.

The PRESIDENT said this was part of the discussion arising out of the Report; but the amendment might follow the adoption of the Report, because the Report did not take up or decide any question in relation to it. The Report only referred to that which had been already done, and it would be quite competent for Mr. Thorburn to move a resolution on this subject when the Report had been adopted, because in adopting the Report they did not adopt any new arrangement whatever.

The resolution that the Report be adopted, printed, and circulated, was then put and carried.

The RETIRING PRESIDENT: It now becomes my duty to vacate this chair in favour of the President who has just been elected. I am sure I have to thank you all very sincerely for the kind manner in which you have always received me, and the assistance you have rendered me. I can only say that I have spent a very pleasant year, and I only hope my successor will have an equally pleasant one.

Mr. ASHMEAD then vacated the chair, which was taken by Mr. G. F. Deacon, M. Inst. C.E., Borough and Water Engineer of Liverpool, as President of the Association for the ensuing year.

The NEW PRESIDENT said: Gentlemen, I thank you very much for the honour you have done me in electing me to this chair. Although to-day there are only a very limited number of the Engineers and Surveyors of the Rural and Urban Sanitary Authorities present, still, as a body we represent a very large and important section of the profession of a civil engineer, and I am hopeful that at future Meetings, by certain steps which have been proposed, we shall be enabled to increase the number very considerably. I am satisfied that only by an Association of this kind can we hope to raise the standard of the particular branch of our profession to which we belong; and I think we must all agree that, speaking generally, it is desirable that that standard should be raised. Once more, gentlemen, I beg to thank you for the honour you have done me. Mr. Thorburn, if you have any resolution to propose now, we shall be glad to hear it.

Mr. Thorburn said the resolution he wished to propose was to the effect, that in future copies of the papers in print be forwarded to the Members of the Association.

The Hon. Secretary: Will you say "proof" copies?

The President said he must ask the Secretary whether the motion was quite consistent with the Report which had been adopted.

The Hon. Secretary replied that the resolution was:—"That in future proof copies of the various papers to be read at the District Meetings be forwarded to those Members who express their intention of attending the said Meetings."

Mr. Thorburn: That is my meaning.

Mr. Hall said he seconded the resolution of Mr. Thorburn, but it was with the understanding that the papers were to be sent to the whole of the Members.

The President: That is not Mr. Thorburn's present motion. Does anybody second Mr. Thorburn's motion?

Mr. Crabtree (Southport): I beg to second it.

The President: The motion moved by Mr. Thorburn and seconded by Mr. Crabtree, which has just been read, is now before the Meeting. Is there any amendment on it?

Mr. Lobley thought it was important that every Member of the Association should have a bound copy as usual.

The President: That is to be so: that is quite clear.

Mr. Lobley: It is not clear to my mind.

The President: You have approved of the Report of the Council, and that, as I understand, includes it. Members will still continue to have the bound copy.

Mr. Lobley: Every Member of the Association?

The Hon. Secretary: Yes; there is no resolution to rescind the previous resolution.

Mr. Lobley: I thought we were to send the folded and soiled copies to be bound.

Mr. Thorburn: I don't go so far as that.

Mr. Lobley: Then every Member will receive a bound copy as usual?

The Hon. Secretary said the copies the Members had hitherto been receiving had been corrected copies sent to each Member after each Meeting, the said copies to be sent up to the Secretary, if the Members thought proper, to be bound. On the other hand, Mr. Thorburn's resolution simply referred to the necessity of sending out a proof-copy to each Member previous to any District Meeting, that he might be prepared for discussion at that Meeting—a copy altogether apart from the copy he would receive afterwards.

Mr. Lobley said he simply wished to obtain the opinion of the Meeting on the question of every Member of the Association having a clean, unfolded, uncreased copy of the Proceedings at the end of the year. Anything else he was quite willing to vote for. He was quite willing to vote for the proof copies in addition, but the first *sine quâ non* was that every Member should have a clean copy, as before.

Mr. Ellice-Clark moved as a rider to the resolution: "That every Member be furnished with two copies of the Proceedings—one in conformity with the resolution of the Council which directs it to be sent out within three months of the Meeting, and a second copy bound at the end of the year."

Mr. Proctor (Bolton) seconded this. He said he was unfortunately one of those who had not received each copy. He thought it would be by no means a waste of paper that each Member should have a copy of the Proceedings immediately after the Meetings.

The President asked Mr. Clark whether his intention was that the second copy should be paid for extra by the individual Member who wished for it, because if not he thought it was a matter which would have to go back to the Council to be discussed on financial grounds.

Mr. Ellice-Clark thought it was a proper matter for the Council.

The President said now that the Council had heard the feeling of the Meeting, perhaps the Meeting would be satisfied to leave the matter with them. It must depend on the subscriptions.

Mr. Vawser (Warrington) was under the impression that the better plan would be to test the feeling of the Meeting upon Mr. Clark's resolution, and see whether the Meeting generally approved of the policy set forth in it, and then let the matter be referred to the Council for further consideration, and let the Council develope some plan by which the resolution could be carried into effect. He was under the impression that the funds at the disposal of the

Council would be sufficient to meet the slight extra expense they would be called upon by the resolution to incur, and, if not, it would be met by a slight addition to the subscription. No doubt, the Council could elaborate some plan, and it could come before the Members at a future Meeting in proper form.

The PRESIDENT suggested that Mr. Thorburn should add to his motion a clause to the effect that sufficient copies should be kept in hand for any Member to obtain an additional copy at a certain price.

Mr. THORBURN: That is a matter of detail.

The HON. SECRETARY: Mr. Clark's amendment is: "That every Member be furnished with two copies of the Proceedings—one in conformity with the Resolution of the Council, and a second copy bound in a volume at the expiration of each year."

Mr. THORBURN did not see that this was an amendment on his motion at all. According to the present custom, the Members did receive two copies. After the District Meetings they received a copy of the Proceedings, with the discussion, and at the end of the year they receive a bound copy of the whole of the Proceedings for the year. (Several Members: No, no.) Then he very much misunderstood what the orders of the Council were. Hitherto it had been the custom to send a bound volume to each Member. (A Member: That is to cease.) He was not aware that any change had been made as to that. The intention in his mind when he moved the resolution was that what he proposed should be in addition to what had been done hitherto. He should certainly not have moved it if he had for one moment thought that the Council were recommending that the annual volume should be discontinued.

Mr. ELLICE-CLARK: Will you accept my rider to your motion?

Mr. THORBURN: Certainly.

The HON. SECRETARY could not help saying, having the thing at his fingers' ends, that this had arisen from a simple circumstance over which the Council and himself had no control. The issue of the earlier Proceedings was unfortunately delayed. This created a great deal of feeling amongst Members, because the information contained in them was not supplied to them for two years after it was given, and this brought about the issue of the Proceedings immediately after each Meeting. If the ordinary course had been followed, the Proceedings would have been out certainly within six months of the last Meeting; but now he could not help thinking that they were drifting into very considerable expense if they were first to send out proof copies, to follow that up by sending a fair and corrected copy to each Member, and then at the end of the year to send out the bound volume.

Mr. Thorburn thought it was quite right that this should be done. The circulation of information in matters of this sort was the life and soul of the Association.

Mr. Hall (Toxteth Park): How many volumes have been issued altogether?

The Hon. Secretary: Three, and there is one now coming out.

Mr. Hall: I have got one out of the three.

The Hon. Secretary: I question whether there is another Member of the Association who has not got his volumes.

Mr. Hall thought it was very desirable that they should have a volume year by year. When the Proceedings were received in pamphlet form they were thrown aside and seldom read, but when they were sent complete in one volume they were often referred to.

Mr. Lobley thought that every Member should be supplied with the annual volume, and that those who desired the proofs and pamphlets in addition should be furnished with them, on payment of the extra cost.

Mr. Proctor said that was not the place to discuss these minor details. He thought the whole question should be referred to the Council.

The President said he thought the Council now knew what the feeling of the Meeting was, and if they could do the whole of what was proposed within the limits of their means, no doubt it would be done.

Mr. Morant (Leeds): Will there be any objection to let it be quite understood that under any circumstances the bound volume will be issued as heretofore, and that the Council will do what they can with regard to issuing the pamphlets?

Mr. Thorburn and Mr. Ellice-Clark said they would be very glad to leave it to the Council on that understanding.

The Hon. Secretary: Will you substitute a resolution that the question of printing be referred to the Council for consideration?

Mr. Thorburn: Yes; then the Council can exercise their own discretion as to how it shall be done.

Mr. Parry (Reading): I will second that. I am so convinced of the necessity of spreading this information amongst the Members that I don't fear the expense at all. You will see very shortly that for want of information a great many Members have not paid their subscriptions, and I believe that when proper information goes round to them the statement of accounts will show much more favourably than it does.

The Hon. Secretary: Mr. Thorburn has moved, and Mr. Parry has seconded: "That, after the present discussion of the question of printing the Proceedings, it is considered desirable that the whole matter shall be reconsidered by the Council."

The President then put the resolution, which was carried.

Mr. Lobley (Hanley) said he had very great pleasure in moving, "That the thanks of the Association are due to Frederick Ashmead, Esq., for the way in which he has conducted the business of the Association, and for his assiduous attendance at the Meetings which have been held in the various districts in the country." He (Mr. Lobley) had attended several of the Meetings, and at every Meeting he had found Mr. Ashmead in the chair. He was not present at the Sheffield and Bradford Meetings, but he believed Mr. Ashmead was there; and he was sure that those who went to Bristol would never forget their visit and the interesting works they saw carried out there by Mr. Ashmead, and the kind way in which he showed them round. He was very much pleased indeed to have been called upon to move this resolution, and the suddenness of the call must be his excuse for not making a long speech upon it.

Mr. Pritchard (Vice-President) said it gave him infinite pleasure to second the resolution. He thought the Association was very much indebted to Mr. Ashmead for what had been done; he might say the resuscitation of the Association was due in a great measure to the energy displayed by Mr. Ashmead in removing the difficulties referred to by the Secretary in connection with the Proceedings. He believed he was correct in saying that Mr. Ashmead had attended every District Meeting during his year of office. They had in Mr. Ashmead a gentleman who had not been afraid of trouble or expense in furthering the interests of the Association, and he thought it was their bounden duty to accord to him their unanimous vote of thanks for the great interest he had taken in it during his year of office.

The President: Gentlemen, I assume from the demonstration you have just made that there is no dissentient voice on this motion. I myself have had the pleasure of meeting Mr. Ashmead on several different occasions—I regret to say not on anything like all—and

I can bear witness to the great energy which he has manifested in the furtherance of the objects of the Association.

The motion was put and carried by acclamation.

Mr. ASHMEAD (Past-President): Mr. President and Gentlemen, I hardly know how to express my thanks for the very kind manner in which the resolution has been proposed and received by you all. I can only say that I have the interests of the Association at heart, and have done my best to promote them on all points; and one thing which has not been alluded to has been a source of great gratification to me, viz. the establishing of another District during my year of office. I only hope the Association will go on and prosper.

This concluded the formal business of the Meeting, and the Members adjourned until a quarter to three o'clock.

THE PRESIDENT'S ADDRESS.

The Members reassembled shortly before three o'clock, when the Mayor (Mr. A. B. Forwood) and Mr. Councillor Whitley were present as visitors.

The President delivered the following address:—

In assuming for the first time the chair to which you have done me the honour to elect me, I wish to welcome you heartily to the second city in the kingdom, and to express the hope that you will not fail to find in Liverpool some works worthy of your thoughts, and to acquire some new and useful information such as I have invariably gathered on similar occasions in the different towns which we have previously visited.

The Association of Municipal and Sanitary Engineers and Surveyors is now holding its Fifth Annual Meeting, and it is desirable to bear in mind the objects for which it was formed.

Those objects are clearly set out in the Rules of the Association as follows:—

> (*a*) The promotion and interchange among its Members of that species of knowledge and practice which falls within the department of an engineer or surveyor engaged in the discharge of the duties imposed by the Public Health, Local Government, and other Sanitary Acts.
>
> (*b*) The promotion of the professional interests of the Members.
>
> (*c*) The general promotion of the objects of Sanitary Science.

The first Public Health Act was passed in the year 1848, and by this Act, and the Towns Improvement Act of 1847, the appointment of Surveyors was authorized in the towns and districts to which those Acts were applied, for the distinct purpose of carrying out the practical work involved in the improvement of the sanitary condition of the country.

As a class of Engineers and Surveyors, therefore, our existence dates back for only thirty years; and it appears to me that no small credit was due to the Municipal Government of Liverpool when, six years earlier, they obtained a Local Sanitary Act, the provisions of which were so well considered by the Council of the day, that many of them have not been improved upon, and are to be found in the most recent sanitary legislation. Under this Act I believe the first Borough Engineer was appointed.

No class of men know better than we do ourselves that the choice of candidates to perform the duties of our office has not at all times been the happiest, and that in many instances the standard of professional knowledge which sanitary authorities have succeeded in securing has been far too low. It may be that the standard has generally been as high as the remuneration could reasonably be expected to command, but if that standard were raised, the remuneration would inevitably rise also, for in the long run there is little to be feared from the competition of those whose practice is obsolete among the leading professional engineers. The Members of this Association (and I am happy to say that we include the engineers and surveyors to nearly all the principal Urban and Sanitary Authorities in the kingdom) meet together, from time to time, to widen our knowledge by visiting each other's districts and works, by examining the causes of increased efficiency or diminished cost, and by thus adding the experience of our neighbours to that gained in the comparatively limited sphere in which our individual duties lie.

Until the formation of this Association, five years ago, many of us knew little or nothing of the mode of carrying out works in places with which we were not directly connected. Some of us had, undoubtedly, made isolated visits, but it could not be expected that in each instance the same facility for obtaining information in a short time could be afforded, as has been tendered to us in our corporate capacity, by the various towns in which we have met. To explain his works to each of a hundred different people would severely try the most patient Borough Engineer, but we may reasonably expect to obtain from him all possible information when we invade his town a hundred strong once in many years. And so, in effect, we have found it to be, for we have never failed to receive from the Municipal Engineer or Surveyor most useful and interesting accounts of the works under his charge and of the results which those works have produced. The whole of those communications, with the subsequent discussions upon them, have been from time to time embodied in the printed Minutes of our Proceedings, and are now in the possession of each of the 163 Members of the Association.

It cannot be doubted that such a change is productive of unmixed good; and it gave me great pleasure to hear recently that one of the smaller Sanitary Authorities had so far recognised the utility of our organisation as to encourage their surveyor in a very substantial manner to attend the Meetings. How many other cases of the kind there are, I do not know. But however gratifying such recognition may be, it must not be forgotten that to yourselves, and to yourselves alone, is due the formation and successful maintenance of the Association at the cost of much personal trouble and expense.

You have each received a printed account of some of the various works which I shall ask you to inspect. From that account you will be enabled to gather information not only concerning the existing state of sanitary engineering in Liverpool, but also concerning the changes which have been effected within the last few years. Before asking you to consider the works, I will endeavour to show you that, judged by the mortality of Liverpool, the existing state of sanitary engineering is satisfactory, and that, judged by the decrease which has recently taken place in that mortality in relation to other places, there is the best reason to conclude that the changes described in the paper before you have given most important and satisfactory results.

Excepting the soil upon which Liverpool is built, there is nothing, I believe, in the physical geography of the district calculated to produce an abnormal death-rate, but the soil is for the most part unfavourable. The rock is everything that can be desired, but over this rock (the new red sandstone) lies in most parts a thick bed of the absorbent but nearly impermeable boulder clay of the glacial period. Before the Borough was almost entirely covered with buildings and pavements, a large portion of the 30 inches of rainfall, absorbed into the boulder clay by capillary action rather than by percolation, was slowly restored to the air when rain had ceased, and produced an abnormally damp climate. But there is a social, and perhaps more important element, which should be taken into account in considering the death-rate.

We have among us a large and ever-changing population of seafaring men, and we have in addition a proportionally large migratory population. Consider for a moment the effect of a multitude of persons moving continuously through the town, to many of them the first dry land for weeks past, to many others the last dry land for weeks to come. Obviously the number of invalids left behind at different times and enumerated by the census on a single night is higher than the actual average number of invalids corresponding to the number of emigrants in the town on any one night. The number of deaths resulting from those invalids must therefore be also higher than the mean death-rate of the population producing them. There are also many other circumstances connected with a migratory, and, in great part, very poor population, which are inimical to the health of residents themselves.

But there is a third and still more important cause tending to increase the death-rate in Liverpool. I refer to the very small area within the Municipal boundary in relation to the population. The population of the Borough of Liverpool is about 532,885, the area only 5210 acres, giving a mean density of 102·3 persons per acre. If we take the seventeen other large English towns[1] which are the subject of the Registrar-General's special reports, and with the death-rate of which that of Liverpool is compared, we find that the total average density of population in them is only 33·6 persons per acre, or less than one-third of the density in Liverpool,—a density, be it remembered, arising in a great measure from the fact that the Borough of Liverpool is only the nucleus of a very large dependent population which in most towns is included within the Municipal boundary. If, notwithstanding this unfavourable mode of comparison and the other adverse circumstances to which I have adverted, it can be shown that the total death-rate from all causes is not exceptional, and that the deaths from those diseases which are generally regarded as dependent upon sanitary measures are actually less than in most other towns, there will, I think, be an additional reason for believing that the Municipal Engineering work of Liverpool is worthy of your consideration.

In an address which, as it appears to me, is among the ablest to be found in the archives of any association, Mr. Hawksley, as President of the Health Section of the Social Science Congress in 1876, compared the total mortality of Liverpool with that of the other large cities most nearly approaching to it in magnitude, viz. Manchester and Glasgow, and from the year 1869 to 1875, inclusive, he found from the Registrar-General's official returns that the mean annual death-rates of the three cities were almost exactly alike.

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[1] The towns are London, Portsmouth, Norwich, Bristol, Wolverhampton, Birmingham, Leicester, Nottingham, Manchester, Salford, Oldham, Bradford, Leeds, Sheffield, Hull, Sunderland, and Newcastle-upon-Tyne.

Liverpool gave 30·1 deaths to each 1000 persons living.
Manchester „ 30·1 „ „
Glasgow „ 30·5 „ „

or 30·1 deaths in Liverpool, as compared with a mean of 30·3 deaths in Manchester and Glasgow.

Since the date of Mr. Hawksley's address two more years have passed, and the death-rate of Liverpool still bears the comparison satisfactorily. I will now give you the mean annual death-rates from 1869 to 1877 inclusive:—

Liverpool gives 29·4 deaths to each 1000 persons living.
Manchester „ 29·7 „ „
Glasgow „ 29·3 „ „

or 29·4 deaths in Liverpool, as compared with a mean of 29·5 in Manchester and Glasgow. Even when the deaths from all causes are considered, it is evident therefore that Liverpool is not, when compared with other similar places, the abnormally unhealthy city which people are in the habit of supposing it to be.

But, as an Association of Sanitary Engineers, it appears to me that we may more usefully investigate the mortality from certain zymotic diseases which are generally believed to be affected by such surrounding conditions as a Sanitary Authority can control.

The causes of death separately distinguished in the quarterly returns of the Registrar-General, are smallpox, measles, scarlet fever, diphtheria, whooping-cough, fever, diarrhœa, and violence. In the annual returns, the causes are further subdivided; but, in order to bring the information up to this date, I am compelled to select from the above list.

If we take scarlet fever, diphtheria, fever, and diarrhœa, we shall, I think, include the representative zymotic diseases which are more directly affected than others by the efficiency of our sewers and drains, including their ventilation, flushing, or capacity for self-cleansing and their pneumatic separation from dwellings; the impervious paving and cleanliness of our streets and courts; the ventilation between our blocks of dwellings, the efficient removal of refuse, and last, but not least, the purity of our water supply, including not only the purity of the source, but the maintenance of that purity by a constant high pressure in the mains, and I must add also the absence of great waste of water, and the consequent greater dryness of our houses and basements.

Now, if we compare the mean death-rate of Liverpool for the years 1875–6–7 and the first quarter of 1878, from scarlet fever, diphtheria, fever, and diarrhœa, with the corresponding death-rate in the seventeen towns already referred to, we find that in only seven of those towns is the death-rate lower than in Liverpool, though the mean density of population in Liverpool is three times as great. It is clear, therefore, that among the eighteen English towns specially enumerated in the Registrar-General's official reports, Liverpool holds a very satisfactory position, if the comparison be based on the deaths from the zymotic diseases above referred to.

If we compare the mean death-rate in Liverpool thus determined with the corresponding death-rate for the five previous years, viz., 1870, 71, 72, 73, and 74, we find a diminution of 46 per cent., while in the corresponding period the mean diminution in the other seventeen towns is only 23 per cent. For so exceptional a change in Liverpool we naturally seek for a visible cause. I am aware that the periods compared are shorter than they ought to be for purposes of the kind; but, if I go back ten years from 1874, instead of five, I find the comparison still more favourable to the more recent period.

Now, the division of the two periods of which I have compared the mortality from certain zymotic diseases was a time when many important sanitary works were in progress, or about to be commenced. I will enumerate a few of these: 81 miles of sewers in the heart of the town have been thoroughly ventilated; 44 miles have been thoroughly cleansed; a large proportion of the whole have been renovated and rendered self-cleansing, as explained in the paper before you, and others have been provided with flushing tanks, and are now systematically flushed; 300,000 square yards of pavement formerly pervious to moisture have been reconstructed and rendered impervious. The connections between 1851 drains in the cellars of court-houses (the traps of which were often defective) and the sewers have been cut off, and pneumatic separation between drains within and without dwellings of all classes is now common, though far from being as universal as it ought to be. Under the medical officer's advice, large numbers of insanitary cellars have been closed; and during the last eighteen months 2178 of the remaining privies have been converted into water-closets.

I have yet one fact to tell you. Before the last day of 1874, the division of our two periods of death-rate, a constant supply of water under high pressure had been afforded to 200,000 persons in the borough, instead of the former intermittent service, and on the last day of 1875 intermittent service was discontinued in the last remaining intermittent district, never again, I trust, to be reverted to.[1] In conjunction with this change the flushing of water-closet drains has, in a large number of cases, been rendered highly efficient where it was formerly inadequate, and the waste of water has been so greatly diminished, that where the foundations and cellars of dwellings in the lower parts of the town were at one time saturated they are now perfectly dry. The change has moreover proved to be a great financial success.

I will not ask you to believe that the whole of the greatly-reduced mortality from zymotic diseases is due to the sanitary changes I have enumerated, though I think you will agree with me that the coincidence indicates a very important connection between them.

But I have already occupied too much of your time, which would be more profitably spent in considering the various papers to be brought before you. I will only say, in conclusion, that although much good work has already been done, much still remains to be done. There are defects in the sanitary works of the best of our towns, to which the eyes of our legislators and the public must be more fully opened before the remedy will be found. We are still very far from the "Hygeia" which has been pictured by Dr. Richardson in such glowing colours, but however sceptical we may be in the immunity from certain diseases promised there, and of the greatly extended life of man under such conditions, we cannot, as Municipal Engineers and Surveyors, do better than conceive for ourselves a city in which all public works, and I am bound to add certain private works, have been executed in the most perfect manner, and to raise to that standard so far as possible the centres of population in connection with which each of us holds so important a trust.

The HON. SECRETARY said one could almost regret that the rules of the Association—and, he believed, the rules of every other association throughout the kingdom—precluded any discussion of the President's address, for there were many points upon which one would have very much liked to raise questions and gather still further information than that which had already been given, which was very clear and explicit and most interesting. They had learned more about Liverpool in the last quarter of an hour than perhaps they had ever known before; and when they heard the President's paper, which was in effect a continuation of his address, and visited the works referred to as practical expositions of the paper, they would then be still more delighted with what they had heard. He begged to move "That the thanks of the Meeting are due to our President for the able address he has read."

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[1] By reason of the great waste of water, constant service had to be abandoned in the year 1865, and for ten years the borough was subjected to all the evils of intermittent service.

Mr. Ashmead (Past-President) seconded the motion, which was put to the Meeting by the Hon. Secretary, and carried.

The President said the next business was the consideration of a number of "Notes" which he had put together for the guidance of the Members in visiting Liverpool works.

The following paper was then read:—

NOTES AS TO CERTAIN MUNICIPAL WORKS IN LIVERPOOL.

By G. F. Deacon, M. Inst. C.E., Borough and Water Engineer, Liverpool.

EXAMPLES OF LIVERPOOL PAVEMENTS IN COURSE OF CONSTRUCTION on 25th, 26th, and 27th July, 1878.

Chapel Street and Old Hall Street, or New Quay.	Portland cement concrete and bituminous concrete foundations for stone-set pavements, with asphalte joints.
Ashton Street out of Brownlow Street	Artificial asphalte pavement.

Portland Cement Concrete for Carriage-way Foundations.

A layer of shingle or of hard stone, foundry slag, or brickbats broken by a stone-crushing machine, is spread over the excavated surface; upon this is scattered a layer of Portland cement mortar composed of one part of cement and six parts of river gravel. Upon this is spread a second layer of broken stone, which is beaten into the lower layer by flat iron beaters, like heavy spades. These operations are repeated until the required level is obtained, when the surface is smoothed off to the exact curvature of the carriage-way. The thickness of concrete employed is $7\frac{1}{2}$ inches for heavy traffic, and 5 inches for light traffic. The concrete is mixed on boards each 4 feet by 3 feet, with their sides 9 inches high, the bottom lined with sheet iron. On the middle side is hinged an open top box, having a capacity of 1 cubic foot, so placed that when tipped up its contents are emptied into the board. The boards are placed in rows, with a movable galvanized iron cistern, supported on legs about 4 feet high between each pair. This cistern has a pipe tap and rose projecting over each adjoining board. Each board is worked by one man; another man fills the measuring-boxes with gravel, and a boy follows with a measure of $\frac{1}{6}$ cubic foot of cement for each board. Each mixer tips up his gravel, and turns it over with the cement until they are thoroughly incorporated. He then turns on the water, and allows it to run through the rose; as the water flows, he turns over the mixture on to it. The mixture is thus uniformly wetted, but care is taken only to allow it to become so moist that when squeezed in the hand it appears wet. If more water is employed, the concrete cannot be effectually beaten when in place. As each cubic foot of mortar is prepared, it is wheeled off and deposited *in situ*. Experience shows that 1 cubic foot is about the quantity that can be most efficiently mixed by one man, and that the flow from the fixed rose saves much labour. Where machine-mixing cannot be well employed, the method above described is probably the most efficient.

For pavement foundations only the best slow-setting Portland cement is used, and the concrete is allowed to stand for ten days before paving is commenced.

A piece of such concrete afterwards cut out exhibits no lamination, but the broken stones are thoroughly interlocked with mortar between them. The proportion of Portland cement to mixed broken stone and gravel is only about 1 to 11. But the concrete is remarkably strong, a result chiefly due to the high quality of the cement, and to the care taken in mixing and ramming it.[1]

No difficulty has been experienced in reaching defective gas or water-pipes; and there is strong reason to believe that the number of defects in pipes has greatly diminished in those streets in which pavements with concrete foundations have been adopted. When it is necessary to take up a piece of pavement the concrete is not broken up promiscuously, but is sawn out with a saw-pick in pieces 3 or 4 feet square and laid aside. Before replacing it the ground is well rammed and watered; the large blocks are placed in their proper positions, and the broken pieces of concrete mixed with Portland cement are filled into the joints. The pavement may be relaid at once, and the traffic passed over the trench on the following day. In no case has any sinking occurred in this portion, whereas in the old method of paving, in streets of heavy traffic, it was necessary to lift and relay the pavement three and sometimes four times before the trench became thoroughly consolidated.

Bituminous Concrete for Carriage-way Foundations.

Where it is found, in the process of reconstructing a pavement, that a hard foundation exists within 3 or 4 inches of the under-sides of the old sets, which it is not desirable to disturb, it is better not to fill the space with Portland cement concrete (which in so thin a layer, would be liable to crack), but to adopt bituminous concrete, which is semi-elastic, but equally impervious. Such concrete may also be used with advantage where it is important not to have the street closed longer than necessary, but it possesses nothing like the strength of Portland cement concrete, which may be regarded as everlasting; whereas concrete containing pitch is liable to deterioration in course of time, though, if well protected from the air, as in the case of street foundations, there is no known limit to its duration. This concrete is composed of clean dry broken stones, consolidated by the use of a heavy roller; boiling pitch and creosote oil, of a consistency which can only be determined by experience, are then poured over it, and all the interstices thereby filled; the surface is covered with smaller stones of about 1-inch gauge, which are rolled into the asphalte, and finished off to the required curvature.

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[1] As to the Portland cement, see page 29.

Set Pavements with Asphalte Joints.

Upon the above-mentioned foundations, stone sets are close paved on about 1 inch of sharp sand. Before ramming, clean gravel riddled through a ¾-inch sieve, and retained by a ¼-inch sieve, is brushed over the pavement; the pebbles are then shaken down by ramming the paving; more pebbles are laid, and the process of ramming repeated until the joints are perfectly filled, and asphalte of boiling pitch and creosote oil is then poured over the whole pavement, and fills the joints precisely as in the case of the bituminous concrete. The system of constructing pavements with asphalte joints is common in Lancashire, and was copied by Liverpool from Manchester. It renders the surface of the carriage-way absolutely impervious to moisture, and thus prevents the unequal sinking which takes place in ordinary pavements, owing to the percolation of water into the subsoil; but experience in Liverpool has shown that, except where the traffic is very light, a concrete foundation in addition is desirable.

Artificial Asphalte Pavements.

For carriage-ways a pavement constructed precisely in the same manner as the bituminous concrete foundation above described, with the exception that the upper surface should not be formed of very hard stones, answers well where the traffic is light. If the upper layer of stones be too hard, the asphalte wears out from between them, and the impact of traffic upon the projecting stones soon loosens them. Limestone answers well for the upper surface. In bye-streets where there is little through traffic, the pavement is excellent in a sanitary sense, as it is quite impervious, smooth, and easily cleansed.

The first impervious pavements were constructed in Liverpool in the autumn of 1872, and since that time about 300,000 square yards have been laid.

Cost of the Different Kinds of Work Described Above.

Portland Cement Concrete Foundation.	Per superficial yard of 6 inches thick.			Total per superficial yard.		
	£	*s.*	*d.*	£	*s.*	*d.*
Broken stone (crushed by stone-breaking machine), including cartage to breaker and from breaker to site			9			
Gravel and cartage			11½			
Cement and cartage		1	3½			
Labour			6			
Total for Portland cement concrete, 6 inches thick ..					3	6
Set Paving.	Per superficial yard.					
	£	*s.*	*d.*			
Sets 6 inches deep, average		7	6			
Sand for bedding 5*d*., cartage 3*d*.			8			
Gravel for racking			1½			
Pitch and creosote oil asphalte, including labour, boiling, and mixing			9			
Labour in paving			6			
Watching and superintendence			3			
Total for set paving					9	9½
Grand total for paving with 6 inches of Portland cement concrete foundation 6 inches deep					13	3½

LIVERPOOL TRAMWAYS.

Some observations of the author's with reference to tramways are to be found at pages 35 to 37 of the third volume of the Proceedings of this Association. It is only necessary at the present time to draw attention to the mode in which the principles then enunciated have been carried out in practice. The models and plans explain themselves.

The greater part of the inner circle of tramways and those in Renshaw Street have been reconstructed according to plan.*

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* These plans and plates referred to in this paper were exhibited to the Meeting.

On examination of the lines as laid down it must be admitted that this method has proved completely successful.

The joints maintain their positions, the pavement remains level with the rails, the points and crossings wear well and remain firm, and no inconvenience whatever to the wheels of ordinary vehicles arises from the existence of the rails.

For towns of lighter traffic than Liverpool and for branch lines and suburban tramways in towns of heavy traffic, the first method of reconstruction adopted may be thought too expensive. A modification involving the same general principles of construction has therefore been devised, and is shown on plan. In the most approved form of that modification, either the whole tramway width (8 feet for each line) is laid with concrete below the level of the sets, or a sleeper of concrete is formed beneath each rail. In the concrete are imbedded at distances of about three feet, jaw-shaped castings, the upper sides of which are flush with the surface of the concrete. The head of a bolt is then inserted into the jaw which holds it in such a manner that though it is free to move laterally it cannot be drawn upwards. The bolts pass freely through vertical holes in the sleepers and tightly through vertical holes in the T-shaped rail. The upper end of each bolt is embraced by a phosphor-bronze nut which is sunk below the groove. The bolt and nut are coated with red lead, and a water-tight joint is thus formed between them and the rail. Before laying the rail, hot asphalte, which will remain moderately soft when cool, is poured into the holes in the sleepers and jaw-castings, and is painted over the sleeper grooves. The rail is then screwed down and remains perfectly firm. It may be lifted and relaid at any future time without disturbing any portion of the adjoining pavement. The joint between the bolt and nut and the rail remains tight by reason of the bolt head being perfectly free to move in the jaw casting, so that it partakes of the vibration of the rail.

This system is probably, strength for strength, the cheapest, in which the rail is firmly secured. It is subjected to a severe test from some of the heaviest traffic in Liverpool at the point where Lord Street crosses the ends of North and South John Streets.

SEWER CONSTRUCTION.

A large proportion of the Liverpool sewers are constructed with the local bricks, jointed with hydraulic mortar. Those constructed by the late Mr. Newlands, who was the first borough engineer appointed in this country, are admirable in design and workmanship, and at the time they were built, were among the most perfect works of the kind in the country. Owing in part to the great number of pebbles in the boulder clay of the district, the bricks cannot, however, be made very uniform in shape; some of the pebbles are of limestone, and are calcined in the process of burning, and slake when the bricks are exposed to moisture. Many bricks are thus ruptured after being placed in position. In some of the more recent sewers the author has therefore lined the inverts with Portland cement. The lining in a sewer 3 feet 6 inches by 2 feet is generally carried about 12 inches above the bottom of the invert, and is about half-an-inch thick. The object is to make a perfectly smooth channel for the dry weather flow, and for this purpose it is perhaps the best plan. In other cases, the bricks have been simply jointed with Portland cement mortar, and any irregularities filled up with the same material. The author has also, in some cases, lined the inverts with Staffordshire bricks set in Portland cement mortar with excellent results. In positions in which sewers are liable to be called upon to convey acids, even highly diluted, there is an additional reason for the use of Portland cement rather than hydraulic lime. The lime is acted upon very readily, and the mortar rapidly becomes disintegrated, but in good Portland cement the proportion of lime is comparatively small, and being chemically incorporated with a large proportion of alumina, the action of diluted acids upon it is unimportant.

Before sewer ventilation in the carriage-ways was adopted, the man-hole covers were all of granite, which had to be lifted to obtain access. At present, side entrances to sewers are not thought necessary. When men are employed in sewers, it is always desirable to have a man on the watch at the point of ingress, and when this precaution is taken, there is no reason why that point should not be in the middle of the carriage-way. The entrance man-holes have cast-iron hinged covers, as shown on the drawing. These are found to answer remarkably well.

The heads of all new branch sewers of considerable length are provided with flushing chambers, having a capacity varying from 800 to 2700 gallons. The valve is 18 inches square, and of stone. It is opened suddenly by a jerk given to a chain brought to the surface. Where the street gullies are properly constructed, so as to prevent the passage of detritus, flushing is rarely necessary even at the upper ends of the sewers, as now constructed. In the very large majority of cases they are perfectly self-cleansing.

Sewer gullies have generally insufficient capacity to reduce the velocity of flow during heavy rain sufficiently to prevent detritus being washed into the sewers. In the drawings the past and present gullies of Liverpool are shown. The old flap-valve gully is now nearly extinct. It in no way prevented the passage of detritus, and as it was largely used in macadam carriage-ways, many of the sewers contained considerable deposits of detritus. The water-trapped gullies were a great improvement upon the last, and gave a much better waterway than most of the ready-made earthenware or iron gullies; but it was deficient in width at *c*, and has therefore in a large number of instances been altered to the represented form, which still retains most of the old parts. Newly constructed gullies are made as shown in plan. The cost of such a gully is about 37*s*.

Improvement of Old Sewers.

A systematic cleansing, examination, repair, and improvement of the older sewers, has been carried on in Liverpool since 1873. The joints of sewers have been raked out and pointed with Portland cement mortar. The inverts where the gradient was slight have been lined with Portland cement mortar, and have thus been rendered almost as smooth as porcelain, and more efficient than at any previous time. Where the inverts of branch sewers join the inverts of main sewers at the same level, and the water is deeper in the main than in the branch sewer, the water in the branch is backed up, and the velocity is greatly diminished. A deposit is then almost invariably formed, which creeps up the branch until Nature has asserted her rights by forming a new invert of detritus, when the current, being no longer backed up, has a sufficient velocity to prevent any further deposit. If the level of the branch sewer invert had been at the level of the naturally formed invert of detritus, no deposit would have taken place. In such cases a new invert has been constructed with Portland cement concrete, as in Figure; and although the fall of the new invert has been of necessity less than the fall of the original invert, it has never silted up.

About 35 miles of old sewers have already been restored in this manner with the most satisfactory results.

SEWER VENTILATION.

In 1872–3 the author made a large number of experiments with a delicate anemometer on the currents of air in sewers and drains. The general conclusions arrived at were that the currents were exceedingly capricious; that the extraction of sewer air at distant points only ventilated very short lengths of the sewer, and was practically inefficient. Any system of ventilation by the production of a constant longitudinal current appeared to be most difficult, and quite impossible in sewers not absolutely air-tight. It did appear, however, that when a low-level and a high-level shaft were placed near each other on the same sewer, there was in the large majority of cases a current down the low-level and up the high-level shaft. This led to experiments with sewers opened at many points to the carriage-way and connected at many points with down rain-water spouts, the upper ends of which were not near windows or chimneys. This may be called the transverse system of ventilation, and is, in the author's opinion, the only system which has proved quite satisfactory. Since 1873 the ventilation of the Liverpool sewers has been carried on systematically. There are about 22 carriage-way gratings as down-cast shafts and 47 rain-water spouts as up-cast shafts to every mile of sewer.

There are now about 81 miles of sewers so ventilated in Liverpool, and the work is rapidly progressing.

In addition to this there are about 1000 specially constructed shafts, each about 6 inches diameter, situated in most cases on court drains. The upper ends of these shafts are provided with revolving cowls.

PORTLAND CEMENT.

Portland cement is now largely used in Liverpool instead of hydraulic lime. When mixed for mortar or concrete it attains a large proportion of its ultimate strength much sooner than lime, and its greater cost is for many purposes balanced by its greater adhesive and cohesive properties. As the author has given much attention to the properties of this material, and as he believes that it may with advantage be employed much more largely, instead of hydraulic lime, in sanitary engineering than is usual at present in provincial towns, it may be useful to quote the following extracts from a paper which he communicated to the Liverpool Polytechnic Society on the 20th November, 1877, but which has not, he believes, been otherwise published:—

"Portland cement is produced from silica, alumina, and carbonate of lime, by grinding or mixing clays and limestone or chalk in combination with water, into a compound known as 'slurry,' which, after being dried, is calcined in a kiln. The clinker thus produced is ground to a fine powder.

"The quality of this powder as a cement depends chiefly upon the following conditions:—

"1.—The chemical constitution of the lime or chalk and clay from which it is produced.

"2.—The relative proportions of these elements.

"3.—The duration of the process of calcination, and the temperature of the part of the kiln from which the cement is taken.

"4.—The degree of fineness to which the clinker is ground.

"5.—The time during which it is allowed to remain well exposed to the air, during what is known as purging.

"Now it will be readily understood that the first three conditions may be extremely variable. The chemical analysis of the clay to be used, and sometimes even of the limestone or chalk, is necessary to avoid the risk of failure from this source. There is always a tendency, moreover, to use too large a proportion of the cheaper material, clay; fortunately, however, this defect is readily discovered by gauging a small portion, placing it in water, and then examining it. If too much clay be present, the colour will be a warm brown, as opposed to the cold grey tint of good cement. Such cement generally sets quickly, but never attains great hardness, and its strength is comparatively low.

"The effect of under-burning cannot be discovered by the eye, it generally produces a quicker setting but weaker cement, and the clinker taken from different parts of the same kiln may therefore have very different qualities. *Cæteris paribus*, the slower the rate of setting of Portland cement, the greater its ultimate strength.

"Grinding the clinker is, under any circumstances, an expensive process, and the better the quality of cement, the more difficult it is, so that fineness, the fourth quality, is only attained when known to be insisted upon. When Portland cement is applied pure, or mixed with only two or three times its bulk of sand, great fineness does not appear to add to its strength, but when mixed with large proportions of other ingredients for concrete, an impalpable powder is necessary, the finely divided particles of which, completely covering each grain of sand, form a more perfect cementing film between them; while, when only a low proportion of the sand or aggregate is used, the cement or matrix is in abundant quantity to surround each grain, and greater coarseness does not weaken the mortar.

"When cement is required for concrete-making, it should be so fine that at least 90 per cent. of it will pass through a 50-gauge sieve.

"Portland cement clinker after being ground always contains more or less lime, which, not having combined chemically with the other ingredients, commences to slake by absorbing moisture from the atmosphere. This slaking process, technically known as 'purging,' must be completed before the cement is used, or it will be greatly weakened and deformed by the swelling of the particles of lime. In order to ascertain if any sample has been properly purged, it is only necessary to make up a disc of cement with the smallest quantity of water, thin out the edges, and place it in water. If on the following day there are no hair-like cracks round the edges, it may be taken for granted that the cement contains no injurious quantity of free lime.

"The observations and tests already alluded to are made with the greatest ease, and within a few hours of the receipt of the cement, but the usual test by which the strength of any sample may be compared with a standard requires several days, some trouble, and some expense, for its performance.

"The resistance to compression, and the adhesion and cohesion of any sample of Portland cement, are nearly proportional to each other, and the useful strength may therefore be determined by ascertaining its tensile strength. Accordingly, both on the Continent and in England, the tensile strength has been made the standard, and it is, therefore, most important that this test should be an accurate one.

"*Influence of Form on Strength of Cement.*

"Mr. John Grant (M. Inst. C.E.), in two papers brought before the Institution of Civil Engineers in 1865 and 1871, respectively, has recorded the most extensive series of experiments on the strength of different kinds of cement probably ever made.

"The machine which he used to determine the tensile strength was very similar to that now exhibited. The form of mould and clips which he adopted, prior to 1857, were in general use at the time. The section at the neck was $1\frac{1}{2}'' \times 1\frac{1}{2}'' = 2\frac{1}{4}$ square inches, but as the fracture almost invariably took place, as theory indicates that it must take place, between the inner angles, in the manner indicated by the dotted line, it is evident that the breaking strength was not the true tensile strength of the neck section of $2\frac{1}{4}$ square inches.

"Subsequently, Mr. Grant rounded the inner corners and produced the form, now in general use, and although the minimum sectional area was unaltered, the breaking strength of a given sample of cement was increased from 345·8 to 459·9 lbs. per square inch of that section, 7 days after gauging, and from 449·2 to 511·8, 30 days after gauging, i. e. the blocks with rounded corners were on the average 23 per cent. stronger than the blocks with square corners. Mr. Grant appears to have had some misgivings even as to this improved form of mould, for he tried many other figures, and among them the same new form suspended from knife edges in holes through the centre of each head, but this device was abandoned, as the mould so frequently gave way through the head instead of through the neck.

"It had always appeared to the author that the form, now in general use, must give a result below the true tensile strength of the sample, because it invariably breaks through a section greater than the minimum section, and because the tensile stress and consequent strain cannot be uniformly distributed, but having a maximum intensity near the concave parts, must cause fracture to commence there with a smaller load than would cause rupture if the stress were uniformly distributed.

"It seemed, moreover, that unless the cement throughout the fractured section were perfectly homogeneous, it was highly probable that one or both of the parts immediately adjoining the shoulders where fracture commenced, would have a density dif-

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fering more or less from the mean density. The mean density of different samples might be made exactly the same, but it was impossible to ensure absolute uniformity of density throughout each sample, and the strength would evidently be more or less, as the density near the concave parts was higher or lower.

"One would expect, therefore, to obtain not only lower results, but more variable results from a block of this description, than from one in which the stress was uniformly distributed.

"Following out Mr. Grant's idea in block E, the author designed, in 1872, the form of test block shown at B. There were no corners or sharp curve. The heads were very large, and through the centre of each passed an oblong hole. No knife edges were used within this hole, but the mode by which it was rendered impossible for the stress to be otherwise than central, would be readily understood from the drawing.

"This test-block broke much more nearly at the minimum section than either of the other two, and in order to determine the *increase of strength* which it gave, the two forms B and A were compared in 560 tests with cement of different qualities. In the blocks made from the same cement the quantity of water used in gauging and the mean density of the cement were exactly the same, while the greatest care was taken to ensure an uniform density throughout.

"The average strength of the cement as tested by the A blocks was 647 lbs., and by the B blocks 753 lbs., per 2¼ square inches, seven days after gauging, giving an increased strength of the B blocks over the A blocks of 16 per cent. As stated above, Mr. Grant's experiment showed that the A block was 23 per cent. stronger than the D block.

"In 382 tests made up of sets of two or more pairs, in each of which sets the quality of the cement and other conditions were the same, the average deviation of the breaking weights of the A blocks from the mean was 5·5 per cent. of that mean, while in the case of the B blocks it was only 4 per cent.

"It is usual with some engineers to specify that Portland cement shall have a tensile strength, seven days after gauging, of a certain number of pounds per square inch. From the above considerations it appears that the same cement may vary 39 per cent., according to the form of mould adopted. To avoid errors from this source, and to ensure the more uniform results consequent on a more uniform distribution of the stress, the author has invariably specified the form of mould to be used in the tests, as for example, in the specification, Appendix I.

" *The General Utility of the Test for Strength.*

"The Portland cement upon which Mr. Grant experimented for the Metropolitan Board of Works in 1859 gave an average strength seven days after mixing of 387, a minimum of 75 and a maximum of 719 lbs. per 2¼ square inches, with block D. As the testing proceeded, and as the specification was from time to time made more stringent, the quality improved, and in 1871, when block A was used, the specification required that the cement should be capable of maintaining a breaking weight of 787 lbs. per 2¼ square inches.

"Immediately before any special means of testing Portland cement were adopted in Liverpool, the cement used by the Corporation, and supplied by a most respectable firm, gave a strength seven days after mixing of 300 to 400 lbs. per 2¼ square inches with the A block. The specification at present adopted by the author (see Appendix I.) requires the tensile strength to be not less than 800 lbs. with block B. The actual strength of the cement obtained during the last year under this specification has averaged 871 lbs., and since the tests were instituted the price paid for it by the Corporation has been considerably decreased.

" *Difficulty of Testing on Small Works.*

"With such examples as these on record, it cannot fail to be admitted that wherever the test can be performed it is most desirable to adopt it. 'But,' say some engineers, and probably nearly all architects, 'we cannot at each of our small works and buildings scattered about the country have a testing apparatus such as this, more particularly as the quantity of Portland cement we use may be very small; nevertheless we would use good cement in preference to bad if we could obtain it by any simpler means. The engineers who execute large concrete works take all the best cement, and the makers, knowing that our contractors have no means of testing it, send us the inferior quality, which you would immediately reject.'

"In this statement there is doubtless considerable truth, and the author has endeavoured to remove the difficulty as follows:—

"*Simple Modes of Testing.*

"In Figs. 2, 3, and 4, is shown an arrangement for testing which any clerk of works can put together in a few hours at a cost of a few shillings. The block of cement C is to be tested by transverse breaking, and the specification requires that it shall not break with a less weight than 150 lbs. applied at the centre. 150 lbs. weight of bricks or other material is placed on the board, it deflects the iron or wooden bar, but is prevented by that bar from bearing on the shackles hanging from the test block until a man lowers the end. This he does very slowly, the bar unbends and the test block gradually takes the load it bore. If the whole load is carried for a few minutes, the specified strength has been reached.

"The block C used for this test by the author has a section of 1½ inches square, its length is 10 inches, and the supports are 9½ inches apart.

"The mould may be of wood, and can be put together by any joiner, and the manner in which the block is released from the mould will be readily understood from the sketch.

"Several blocks from each lot of cement should be prepared, and when the moisture has disappeared from the surface they should be placed in water and tested after seven days.

"In practice, the following specification would secure a cement of about the same strength as that employed by the author:—

"*Proposed Specification for Transverse Test.*

"*Samples of pure cement shall be gauged with water, and pressed into a mould* 10″ × 1½″ × 1½″. *The block of cement thus formed shall be placed in water, and after seven days tested by placing it on supports* 9½ *inches apart, and gradually applying a load of* 150 *lbs. on its centre. If more than one out of three blocks are broken within one minute of the application of the load, the engineer* (*or architect*) *shall be empowered to reject the whole of the cement from which the samples were taken.*

"*Portland Cement Setting.*

"One of the qualities of both natural and artificial cements, as distinguished from limes, is their property of quick setting. This peculiarity is valuable in some plasterers' work, and in pointing joints in running water where the mortar would otherwise be washed out; but there are probably few other circumstances in which any advantage is derived from the use of very quick-setting cement. On the contrary, it is exceedingly difficult to ensure its immediate application after gauging, and any remixing greatly weakens, if it does not altogether destroy, the cohesion.

"The best Portland cement has most fortunately the property of setting much more slowly than any other, and it may, therefore, be used with far greater safety in situations where its application cannot be closely watched.

"In certain classes of works it is extremely difficult to place mortar or concrete *in situ* immediately it is mixed. Take, for example, the case of a carriage-way foundation 25 feet wide. The excavated materials must be removed from, and the concrete materials brought to the face of the work by the same route; and if the concrete is to be immediately laid, the mixing apparatus, and the men employed in the work, must be accommodated on the narrow excavated ground, and must be moved back as the work proceeds.

"The great advantage which would arise if the concrete or mortar could be brought to the ground ready mixed, must be apparent to all. To ascertain if this was possible, without deteriorating the quality of the work, the author in 1872 prepared twenty-four blocks of concrete of 1 cubic foot each, and allowed different periods to elapse between gauging the material and moulding it. These blocks were tested by crushing at the material testing machine in Birkenhead, belonging to the Mersey Docks and Harbour Board, with the following results:—

"*Results of tests as to the resistance to crushing of Portland Cement Concrete blocks. Each block one foot cube. Proportion of gravel to Cement, five to one.*

INTERVALS IN MINUTES BETWEEN GAUGING CONCRETE AND FILLING MOULDS.

	0	20	30	40	45	50	60	75	90
Resistance to crushing in tons after 28 days	48·1	>50·0	>50·0	>50·0		47·15	42·15		
Ditto 26 days ..	43·0	48·0	>50·0	47·17		47·0	48·15		
Average ..	45·55	49·0	>50·0	48·58		47·07	45·15		
Ditto 24 days ..	49·15		>50·0		>50·0		49·12	43·1	37·1
Ditto 21 days ..	>50·0		>50·0		>50·0		46·0	>5·00	>50·0
Average ..	49·57		>50·0		>50·0		47·56	46·55	43·55

"It is unfortunate that the power of the machine was limited to 50 tons, and that out of twenty-four blocks, eleven were therefore not broken. But the result proved beyond doubt that on the average those blocks, the concrete of which had stood from twenty to thirty minutes before being placed in the moulds, were actually stronger than those in which the concrete was immediately moulded.

"The author is only able to explain this on the assumption that even in this good and well-purged cement there was some free lime which began to slake on the application of water, thus producing numerous but invisible points of weakness in the blocks first moulded, while in those made with concrete, allowed to stand after gauging, the materials were not moulded until the slaking process was completed.

"APPENDIX I.

"LIVERPOOL CORPORATION.

"BOROUGH AND WATER ENGINEER'S DEPARTMENT.

"*Specification of Portland Cement.*

"The cement must be of uniform quality, and capable of bearing the following tests to the satisfaction of the engineer:—

"1st.—Samples of the cement being sifted through a number 50 gauge wire sieve, must not leave a residue of more than 10 per cent.

"2nd.—Samples of pure cement will be gauged with water and placed in the brass moulds B used by the Corporation. Within twenty-four hours the casts thus made will be immersed in still water, in which they will remain until the expiration of seven days from the date of moulding, when they will be taken out of water and tested to ascertain their tensile strength, which must not be less than 800 lbs. on the sectional area of 2¼ square inches.

"3rd.—In ordering the cement it will be distinguished as quick setting or slow setting. The slow-setting cement, when gauged neat in the B mould, must not become firm in less than three hours. The quick-setting cement must assume a firm condition within half an hour. The test for firmness will be that of resistance to the finger-nail, the test at present adopted in the department.

"The above tests will be applied after each delivery, and should the result be unsatisfactory to the engineer, he may—having given notice to that effect to the contractor within eleven days of delivery—require the whole of such cement to be removed at the contractor's expense.

"With each delivery the contractor shall send a memorandum of the quantity delivered, and the name of the manufacturer.

"George F. Deacon,
"Borough and Water Engineer."

BOOTLE WATERWORKS.

About two-thirds of the water supplied to Liverpool is brought by gravitation from reservoirs at Rivington, 25 miles distant. The remaining one-third is obtained from wells in the new red sandstone. The following is a general account of one of those wells which the Association will visit.

Before any works had been constructed for the purpose of supplying Liverpool from Bootle, the water rose at the site of the present works and flowed over the surface in a copious stream to the river, giving motive power on its way to a paper-mill.

Towards the end of the eighteenth century Sir Clive Moore, Bart., projected a scheme by which it was proposed to bring the water of this spring by gravitation to Liverpool. An Act of Parliament authorizing the works was obtained, and an aqueduct, partly built and partly cut out of the sandstone rock, was constructed. The promoters, however, had evidently a very imperfect knowledge of the permeability of the rock, and naturally, on letting the water into the conduit, it was rapidly absorbed, and flowed through the interstices of the rock to lower levels. The scheme was therefore a failure. Pumps and engines were subsequently erected, and the water was drawn from surface reservoirs excavated in the rock. In the course of time, as pumping was continued, the level of the water fell, and in order to reach it, it became necessary to sink deep shafts and erect new engines and pumps. A heading or underground reservoir (see plan), the lowest floor of which is 105 feet below the surface, connected the different shafts. The length of this heading is about 440 feet, the breadth 18 feet, and the height 26 feet. There are several boreholes in it, the deepest of which is about 630 feet from the surface. When the present normal yield of the well, about 1,500,000 gallons a-day, is pumped, the water which once flowed over the surface stands in the heading at a depth of 97 feet 8 inches from the surface, or 43 feet below the mean sea level. The mode in which the water enters the heading, and the method of gauging the flow from the different parts, may be inspected. The present engine is of the Cornish type, with a 56-inch cylinder, and a stroke of 10 feet. It drives single-acting force and lift pumps.

Last year the sinking of a new borehole was commenced from the surface close to the above-mentioned heading. The promoters of this scheme anticipate that an additional supply of 1,428,571 gallons a-day, or 10,000,000 gallons a-week, will be thus obtained, and that the water supplying the upper well may be separated from that supplying the deep borehole, by means of a water-tight joint between the rock and the tubing up which the water rises. The borehole is 26 inches in diameter, and has already been sunk to the depth of 960 feet. The depth to which it is intended to be sunk is 1000 feet.

The apparatus used in boring is a modern application of the old Chinese rope-boring machine. The machinery is designed by Messrs. Mather and Platt, of Salford, the contractors for the work. It is exceedingly ingenious, and is among the most perfect of its class.

WATERWORKS APPLIANCES, HOTHAM STREET DEPOT.

At this depôt all water fittings authorized to be used in Liverpool are tested and stamped.

Any tradesman may send a new kind of fitting to the engineer, and if that fitting is found to be in all respects satisfactory, it is purchased and placed with the other fittings in the sample room.

No fitting is accepted by the testing officer, unless, in general design and workmanship, it is similar to one of the standard fittings, and passes the internal gauging and testing under pressure, to which all fittings are subjected. Fittings which stand the tests are duly stamped and delivered on payment of the following fees, which render the office self-supporting:—

Bib and stop taps	2*d.* each.
Ball taps	3*d.* „
Closet cisterns with ball taps	6*d.* „

The testing office has been in operation for five years, and during that time about 260,000 fittings of various kinds have been tested and stamped. This, however, considerably exceeds the number actually employed within the district supplied by the Liverpool Corporation Waterworks, as some of the local authorities without the district require Liverpool stamped fittings to be used; and even in places where this is not made imperative, they often command a higher price than ordinary fittings.

On examination, it will be seen that many of the fittings differ considerably from those ordinarily employed in other places. Special experiments, by artificial freezing, have been made, to arrive at forms of cast-iron water-closet regulating cisterns, and stand-pipes for courts, which will not burst when freezing. The result of those experiments has led to the rounding of all the corners of such cisterns to a radius of about 2½ inches, to the adoption of ¼ inch as the minimum thickness of metal, and to the sloping of the sides outwards towards the top at the rate of 1½ inches to the foot from the vertical. The author believes that there is no record of such a cistern having been broken by frost. The self-closing taps made use of for outdoor stand-pipes were protected with equal success by the insertion of a small piece of india-rubber, against which the water expanded in the process of freezing. This device was suggested by the present Chairman of the Liverpool Water Committee. While speaking of water-closet regulating cisterns, it is worthy of mention that, although in most other places in which regulations with respect to water fittings have been adopted, the maximum flush of a water-closet cistern is limited to 1½ gallons, the minimum available flush allowed in Liverpool is 2 gallons, and no objection is made to cisterns giving a greater available flush, provided only that the water cannot flow continuously. When a flush of 2 gallons or more is allowed to flow freely through a 1¼-inch pipe, the flushing effect is most complete.

METERS FOR MEASURING TRADES SUPPLIES OF WATER.

POSITIVE METERS.

The Duncan Meter.[1]—Invented by the late Mr. Thomas Duncan, M. Inst. C.E.

This meter is similar in form to a two-cylinder horizontal high-pressure steam-engine, with pistons carrying a slotted link in which the crank pins work. The pistons have double cup leathers and the stuffing boxes have a small cup leather with hemp packing. The form of valve is a D slide, worked from the shaft by eccentrics, and set without any appreciable lap or lead. The cranks are at right angles and the middle of the slot of the link is slightly enlarged, so that when, for example, the right-hand crank-pin is at the dead point, there is no motion of the right-hand piston and slot until the water freely enters the cylinder to give that motion, which it does when the right-hand valve is opened by the motion of the left-hand piston. By this device an incompressible fluid is accurately measured, and the meter runs even more smoothly than if it were provided with air-vessels at each end of the cylinder, which would obviously destroy the accuracy of the apparatus.

The index is driven from a worm on the crank shaft.

A large number of these meters are in use in Liverpool and other places.

The first cost is high, but for meters above 2 inches the comparatively small cost of maintenance renders them economical in practice.

This meter is frequently used as a hydraulic engine for blowing organs and for driving lathes and lifts.

The Kennedy Meter.[2]—This apparatus is largely used in Liverpool. The water is measured by a single cylinder and piston. The piston is nearly half the length of the cylinder, and the ends thereof are nearly the same diameter as the cylinder, the diameter of the body of the piston being less. Around the smaller diameter is an india-rubber ring, which rolls between the piston and cylinder and keeps the piston water-tight. The stuffing-box is packed with hemp.

The piston rod carries a rack which gears into a pinion. On the pinion shaft is a bevel wheel gearing into two other bevel wheels on opposite sides of the driver. The driven wheels drive their shafts through the media of ratchets in such a manner, that when the rack is rising the shaft of one driven bevel wheel revolves in a given direction, while the second bevel wheel runs loose; and when the rack is falling the shaft of the second driven bevel wheel revolves in the same direction, and the first bevel wheel runs loose. The index is thus driven in one direction only off the shaft carrying the two bevel wheels.

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[1] The Duncan meter is constructed by Messrs. Geo. Forrester and Co., Vauxhall Foundry, Liverpool.

[2] The Kennedy meter is constructed by Kennedy's Patent Water-Meter Co. (Limited), Kilmarnock.

The valve is really a four-way cock actuated at the instant of extreme stroke by a tumbler driven by tappets on the pinion shaft.

In using this meter care must be taken that water cannot flow backwards, or it will be registered as if it had flowed in the right direction.

The Manchester Meter.[1]—This apparatus is also in use in Liverpool.

The water is measured by a single cylinder and piston. The piston is made tight with double cup leathers, and the stuffing-box has one cup leather and no packing. The piston rod actuates an auxiliary slide valve by means of tappets. This slide valve is placed between the open ends of two small cylinders with a common axis. By the motion of the auxiliary slide the water is admitted not direct into the measuring cylinder, but to the back of one of the pistons of the small cylinders. The two small pistons are rigidly connected, and the connection carries the auxiliary valve face and ports, so that while the tappets actuate the auxiliary valve the water entering behind the small pistons actuates the auxiliary valve face as well as the main slide valve, so that although the motion of the tappets ceases immediately water enters the other side of the measuring piston, the motion of the auxiliary piston is continued until the main ports are fully open. The effect of the auxiliary valve and pistons is therefore the same as that of the tumbler in Kennedy's meter.

Other Positive Meters not largely used in Liverpool.—Examples of the ingenious *Union Water Meter*[2] and of the *Worthington Water Meter* may be seen at the Hotham Street Depôt.

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[1] The Manchester meter is constructed by the Manchester Meter Co., Ardwick Street, Manchester.

[2] The Union meter is constructed by the Union Meter Co. (Limited).

Inferential Meters.

The Siemens Meter.[1]—This was the first trustworthy inferential meter, and although many have since been produced, they have failed to give equally satisfactory results. No inferential meter should, however, be employed where ordinary ball cocks are used, as the records at low velocities are seldom correct. In Liverpool a large experience has decided in favour of the above-described positive meters for ordinary purposes.

The Siemens meter is a Barker's mill or reaction turbine giving motion to a worm and wheel which actuate through the agency of other wheels a most ingenious index, in which the gearing is greatly simplified by the fact that the dial-plate revolves as well as the hand in the same direction, but at a different velocity. The differential motion thus produced enables very large volumes to be recorded without great multiplication of gearing and consequent friction.

THE WASTE-WATER METER.

The present form of the waste-water meter is described in the 'Proceedings of the Inst. C. E.' vol. xlii., September, 1874–75, and may be seen in action. To repeat the description, and the system for the detection of the waste of water, in which it is the chief agent, would occupy an undue portion of the Proceedings of this Association. It is sufficient to say that, in Liverpool, house-to-house visitation, for the detection of waste, was abandoned in 1873, when the waste-water meter system was adopted, by means of which the whole of the waste may be detected in a semi-automatic manner.

Since the introduction of this system the staff of inspectors has not been increased, but the following changes have, nevertheless, been brought about:—

	Gallons per head per day.[2]
In 1873 the rate of supply under intermittent service was	24¼
„ under constant service, which, however, could not be maintained, it was	33½
Since 1873 the waste-water meter system has been in operation, and during 1877 the supply averaged under constant service	18

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[1] The Siemens meter is constructed by Messrs. Guest and Chrimes, 85, Southwark Street, London.

[2] These figures are exclusive of the water sold by meter to manufacturers, equal to about 4½ gallons per head per day; but they include from 2½ gallons to 3½ gallons per head per day supplied for sanitary and public purposes, and for trades charged by assessment and not by meter, so that the rate of consumption, including waste, under constant service in 1877, for hotels, public-houses, warehouses, offices, shops, and domestic purposes, was 15¼ gallons per head per day.

In considering the above figures, it should be borne in mind that about nine-tenths of the Liverpool people use water-closets.

The population supplied is 670,000, and if the above saving be multiplied by this population, and by 7*d.* per thousand gallons, which is about the cost price of the water, and by 365, a figure will be arrived at representing the annual value of the saving, which will at once set at rest all doubt as to the economy of the system.

It appears that the saving per head has been still greater in some of the other cities in which the method has been adopted.

The change has certainly saved Liverpool from a great dearth of water, has enabled her to draw, without stint, from a source which in relation to the demand has been abundant since 1875, and which will continue to be abundant in the future for a certain number of years, at the end of which time the supply must be largely supplemented, in order to meet the demands of a rapidly increasing population, and the still more rapidly increasing trades which are dependent upon an ample water supply.

Reducing Valves.

When the waste of water is diminished, the velocity in the mains and the consequent loss of head are diminished also. In Liverpool the increase of normal pressure from this cause was, in some places, as much as 30 per cent.

A pressure much above the pressure required to raise water to the tops of the highest houses in any district is unnecessary, and is always detrimental to the lives of the fittings. Some waste is, moreover, inevitable, and the volume of that waste will, *cæteris paribus*, be approximately proportional to the square root of the pressure. The pressure for fire puposes, however, can scarcely be too high.

In order to reduce the wear and tear of fittings, and to diminish the velocity of flow through any inevitable defects, an automatic reducing valve has been devised, which will be shown to the Association in action. Not only does it maintain any required constant outlet pressure, independent alike of the velocity of flow, and of the inlet pressure, but in those cases in which the distributing mains are likely to be used for fire purposes, it is so arranged that when a hydrant is opened, the valve is thrown out of action, and the full available pressure obtained. These valves have now been in use for about two years in Liverpool. They are being applied wherever the pressure is such that a reduction is desirable for domestic purposes.

THE FOLLOWING LETTER FROM MR. LYSTER, ENGINEER TO THE MERSEY DOCKS AND HARBOUR BOARD, WILL BE INTERESTING IN CONNECTION WITH THE PROPOSED VISIT TO THE NORTH END WORKS.

MERSEY DOCK ESTATE,
ENGINEER'S OFFICE, DOCKYARD,
LIVERPOOL, 16*th July*, 1878.

MY DEAR SIR,

Agreeably to the request in yours of the 11th instant, in connection with the coming visit of the Municipal and Sanitary Engineers, I have much pleasure in handing you a printed tabular statement of the existing docks, graving docks, &c., on both sides of the river, and a pamphlet referring to the grain warehouses; also a general plan of the Dock Estate.

The new works now in progress at the northern and southern extremity of the estate, shown by a pink tint, comprise:—

At the North.—A half-tide dock, leading from the Canada basin, having a water area of 18 acres, and a quayage of 2675 lineal feet, with two graving docks (each 950 feet in length), and a repairing dock, with three acres of water area, leading therefrom.

Northward of this half-tide dock, and in connection therewith, is a system of docks specially designed for the accommodation of the steam trade, consisting of one large dock with three branch docks. The water area of this system is 43 acres, with a quayage of 11,152 lineal feet.

A mineral dock is also designed to the north of the steam dock, having a water area of 18 acres and a quayage of 3850 lineal feet.

The sills of these docks have been laid at a much lower level than those of any of the other docks on the Liverpool side of the Mersey, which will prove of immense advantage to the general trade of the port.

The Canada basin is to be enlarged and deepened, and a special system of sluicing arrangements provided for the purpose of keeping clear the entrances and maintaining the requisite depth within them.

At the South the works comprise:—

A dock leading from the Brunswick Dock, for the use of the inland carrying trade; two large docks to the southward; and an extension of the present Herculaneum Dock; the total water area being 32 acres, and the quayage 11,684 lineal feet; also an additional graving-dock 770 feet in length.

At the commencement of these works, the unsettled state of the labour market was such that I considered it necessary to make their progress and cost dependent as little as possible on skilled labour, and, with that view, Portland cement concrete has been largely used in the construction of the walls, &c., and with the most satisfactory results both as regards stability and economy, the chambers of the graving-docks at the north end having been wholly constructed of that material.

Faithfully yours,

(Signed) GEORGE FOSBERY LYSTER.

GEO. F. DEACON, ESQ.

LIME STREET STATION ROOF. LONDON AND NORTH WESTERN RAILWAY.

The principals of this roof are wrought-iron bowstring girders. The covering is glass and zinc. The width of each span is 190 feet, the length 650 feet, and the rise of the arch 42 feet 6 inches. The open cutting adjoining the station has been recently completed, and is 475 yards in length, 51 feet in width, and 55 feet to 60 feet in depth. The cutting is in the new red sandstone, and interesting sections of that formation are exposed.

DISCUSSION.

Mr. Parry (Reading) asked what time it took, in repairing a road, to cut out one of those pieces of concrete? That process seemed to him to involve the chief labour in the repairing such roads. The concrete was a good thickness, and had to be cut out and replaced.

The President said that one man could cut out a block of one square yard with a saw-pick in an hour and a half to two hours. It took a rather longer time altogether than with ordinary foundations to take up a trench and reinstate it, but in the long run both time and money were saved, by reason of the total immunity from subsequent subsidence, while the diminished nuisance to traffic was an important element. In reinstating the carriage-way over a pipe trench, the block of concrete which had been cut out, and was perfectly hard, was replaced. It was cemented to the remaining pavement, and the cement was sufficiently hard by next day to allow traffic to pass over.

Mr. Vawser (Warrington) noticed that in the method of forming concrete roads in Liverpool very great care was taken to form a very smooth bed for the sets, and this was effected by the method described in the paper of putting in a quantity of rough stone and laying a quantity of smooth concrete on the top. He had always been under the impression that smooth concrete would have great difficulty in getting down among large stones and amalgamating with them. Perhaps the President would tell them whether that was so. He had always thought, from the experience he had had, that it was better to mix the concrete rough and fine thoroughly together before placing it *in situ*, instead of laying a bed of rough material and then a bed of fine. Again, he had found, in making roads with concrete, that after a lapse of time the pavement in certain parts of the road had settled, in consequence of the concrete breaking through, as it were, with the weight of the traffic above. Probably, when they commenced to repave a road, the old pavement .had not been taken up for many years before, and at a distance of some 2 or 3 feet from the surface the street became hollowed out by the earth washing into some of the old drains, or by the defective way in which the old water and gas pipes had been pulled up. He had found that when the concrete had been laid on this—and it could not have been detected when the work was done—the whole pavement had settled down over these particular holes, and the pavement had been to a large extent ruined. This had always struck him as being one of the great objections to foundations of concrete. There were other methods, of course, of making road foundations, with rubble stone, and, for example, where the street was kept open for traffic for a very long time, and in those cases the failure of the foundation of the road was detected before the pavement was laid on, and for that reason they had many advantages over concrete. He should be glad to know whether the President had noticed any failures of that description in his experience in Liverpool, and also whether he found that the rough and fine concrete was thoroughly amalgamated when it was set.

The President said it was a somewhat irregular mode of conducting the discussion, but it was better, when it consisted chiefly of questions, that he should answer at once. The homogeneity of the mass of concrete when it was completed he had spoken of in the paper. The fact was, that if they laid a layer of macadam 3, or less than 3 inches thick, they had large interstices between the stones, and if over that they scattered mortar, and again scattered stone over that, and then beat the three layers down, the stones above were pressed into the crevices between the lower stones, with a film of cement mortar between them; and if they continued that process to 8 or 9 inches they got a perfectly homogeneous mass, without any lamination whatever; and his own experience was that the spaces were often more completely filled up with the mortar and stones than when the whole were mixed together in the first instance, and the cost was very considerably less. He thought they would be satisfied when they had seen the work that perfect homogeneity was obtained, so far as it could be obtained with concrete. With respect to the other point, if he understood Mr. Vawser rightly concerning the formation of holes under pavements, it was that the earth might wash out from a defective sewer or water-pipe and leave the pavement hollow underneath. (Mr. Vawser: Yes.) In the whole of the 300,000 square yards of this pavement laid in Liverpool no such thing had ever happened, but it had frequently happened under very old and hard macadam roads. In Scotland Road, some little time ago, the crown of a sewer fell in for a short distance. Traffic continued to pass over it for some time afterwards, by reason of the strength of the arch of macadam, which enabled it to carry the traffic. Suddenly, as an omnibus was going over it, everything went down, and an enormous hole of the diameter of half the width of the Council Chamber was left. That was the only case of serious magnitude that had happened within his recollection. He had heard of other cases in other towns. That arose from the defective condition of a sewer. So far as water pipes were concerned, there was no doubt that concrete protected them. There were fewer breakages in water and gas pipes under concrete than without concrete, and the number of repairs of any kind whatever under concrete had been exceedingly small.

Mr. ALTY (Barrow-in-Furness) remarked that Mr. Deacon had not given the cost of bituminous concrete or artificial asphalte pavement. He should like to know the cost of such a street as Grove Street. He thought the pavement laid down there was a new thing to most of them.

The PRESIDENT said it was no doubt an omission not to have mentioned the cost of bituminous concrete, but he might state that inch for inch in thickness it was almost precisely the same in cost as Portland cement concrete. The price was about 7*d.* per yard for each inch in thickness. It was only used in some cases as a foundation, because it was elastic, and Portland cement concrete was comparatively inelastic. As a surface pavement, Portland cement concrete did not answer. He was obliged to Mr. Alty for mentioning Grove Street. Some part of Grove Street had been laid more than a year, and he thought it was standing very well.

Mr. ALTY: Then we may take it at 3*s.* 6*d.*?

The PRESIDENT: Yes, for that thickness. For 6 to 7 inches deep it costs 3*s.* 6*d.* a yard. If it is less than 6 inches deep it will cost less, but not quite in proportion to the reduction in depth; if it is more it will cost a little more, but not quite in proportion to the increase in depth.

Mr. JONES (Chester) said he thought he had met with an expression of opinion by Mr. Deacon in favour of 4-inch cube sets, but now he saw that he was using 6-inch sets, and he should like to ask him what was his experience in the matter—where the 4-inch sets had been satisfactory and where they had not.

The PRESIDENT said he had never been favourable to cubes at any time. When he first became Borough Engineer for Liverpool, he found a number of orders for cubes and square sets on hand,

and they were used up under his supervision; but so far as he had had any ordering of sets they had been 6 to 7 inches long, from $2\frac{3}{4}$ to $3\frac{1}{4}$ inches in width, and of two depths, viz., $6\frac{1}{4}$ and $7\frac{1}{4}$ inches. Prolonged experience had satisfied him that this was about the right proportion. The multiplicity of longitudinal joints in pavements formed with square sets was very detrimental to the wear of the pavement.

Mr. Proctor (Bolton) said he noticed that where tramways were laid, the pavement immediately adjoining the rail was made of a harder material, and he wished to know whether the inequalities resulting from that condition of things would not be more difficult to deal with, than if the whole were paved with the same material. There seemed to be a double joint, and already the hard material was showing itself against the soft.

The President said that was, and must always be, a great difficulty in connection with tramways. When they put an iron tramway down with only a moderately hard material such as stone, and the two were subject to the same traffic and wear, one wore out more quickly than the other, and nothing could prevent it from doing so. But it appeared to him desirable to make the change from hard to soft as gradual as possible, and this he had done by making the sets immediately adjoining the rail less hard, of course, than the rail, but harder than the adjoining sets. He had not yet had sufficient experience of the method to speak of it with great confidence. The harder sets which Mr. Proctor had seen were not close upon the concrete foundation: there was a space of from half an inch to an inch of either gravel or cement between them and the concrete foundation. They might always lift those sets and let them down that half inch, if necessary, and they might also plane down the tramway sleepers on the under side. He thought that would prove to be more desirable than taking up the whole of the roadway; but it was quite certain that no mode had been devised, and he did not think any mode could be devised, to keep both sets and rails at the same level continually. They must come as near to it as they could.

Mr. Ashmead (Past President) asked whether, if there were occasion for it, it would be feasible to take out the bolts after they had been some time in use. His idea was that a bite could not be got upon the nut.

The President: Easily.

Mr. Ashmead thought that the abrasion of the flange of the wheel and of other vehicles would wear the head of the bolt so that there would be no hold, and the lower part would turn.

The PRESIDENT said there was abundance of hold. The nut was of phosphor bronze, and exceedingly hard, and there was not the slightest difficulty in taking out any of the old bolts with the key. The upper side of the nut was made at least twice the depth of the flange of the wheel, and he did not think therefore that the flange of the wheel would ever go down so far as to touch the head of the bolt. The bottom of the bolt was filled with asphalte which held it quite sufficiently tight to prevent it from turning.

Mr. MORANT (Leeds) asked whether the lining of all sewers with Portland cement was not a very difficult matter.

The PRESIDENT replied that it was no doubt a very difficult matter; still he regarded it as a very necessary matter. They must have trustworthy men to do the work, and they must be thoroughly well looked after. It was well worth doing. It must be remembered that it was only done for a height of 9 to 10 inches from the bottom of the invert.

Mr. MORANT: But it is in the bottom which is the most troublesome part. You would have to have two dams, and a trough to pass the sewage during the time the work was in hand.

The PRESIDENT: It is a difficult and an expensive matter, but it is a great deal cheaper than either reconstructing the sewer or cleaning it perpetually.

Mr. LEA (Wallasey) asked what was the minimum-sized sewer in which this was found practicable.

The PRESIDENT said there were very few brick sewers in Liverpool, except very short ones, of less size than 3 feet × 1 foot 10 inches.

Mr. MORANT asked if there was not a difficulty in getting the cement to adhere to the bricks saturated with sewage.

The PRESIDENT said the bricks had to be thoroughly cleansed, and all the joints raked out thoroughly; and that was a most difficult thing to get done properly. He could not press this point upon the Meeting too strongly. The difference it made in an old sewer to have it lined in that way with Portland cement was something enormous. A sewer they would think it almost necessary to re-construct to make anything of it could by this means be made almost as good as new—better than many new sewers.

Mr. PRITCHARD (Vice-President) said the question of gradients was a very material one in sewer construction. A great diversity of opinion existed as to what gradients were safe gradients to work with, and he should be glad if the President would give the gradients of the sewers in Liverpool and the one of the least fall which appeared to act well.

The PRESIDENT said his experience was that an outfall sewer, where there was a considerable flow of water, would act well up to 1 in 500, and even higher than that, he believed, though he had no personal experience of anything above 1 in 700. The ruling gradient he adopted for branch sewers was 1 in 240. That could generally be got in Liverpool, but there were plenty of sewers very much flatter than that. Along the line of docks, there were tide-locked sewers with very little fall, and in a tide-locked sewer, no matter what the gradient, they must have a deposit. The water was absolutely quiescent when the tide was against the mouth of the sewer, and if there was detritus in the water it must be thrown down, and he knew of no way in which the sewer could be kept clean except by hand labour or artificial flushing, if the fall were sufficient at low tide to enable artificial flushing to be efficiently performed.

Mr. WHITE (Oxford) thought the use of hydraulic lime was objectionable in any sewer, and not only in those which had to convey acids. His experience was that it was highly objectionable —that there was sufficient acid in every sewer to destroy the lime. He thought Portland cement should always be used.

The PRESIDENT was quite satisfied it was very much safer, but there were sewers in Liverpool, very old ones too, in which the lime of the inverts was in a perfectly good condition. Whether it depended on the degree of hydraulicity of the lime he could not say. Although he thought the joints of the majority of the Liverpool sewers had suffered by becoming disintegrated, and the lime having been washed out, it was not universal; but the Portland cement joints were good for ever.

Mr. BRIERLEY: Do you ever use any Roman cements in joints?

The PRESIDENT: Yes; sometimes where it was necessary that the cement should set very quickly; but he generally preferred to use Portland cement, one to one, or sometimes even neat.

Mr. ELLICE-CLARK (Hove) said that on the subject of sewer ventilation he should like to know whether it had really been determined by a number of experiments that there was in the majority of cases a current down the low level and up the high level shaft. He should also like to know whether the experiment of ventilating sewers by having simply street openings for down-cast shafts, and rain-water pipes for up-cast shafts, had been carried on to a large extent in Liverpool, and whether they had been systematically watched. Whether the currents had been tested with anemometers, and also with, he was going to say, more delicate instruments; for instance, a candle. Sometimes the velocity of air a sewer was so delicate that it would not move the most delicate anemometer used in mines.

The PRESIDENT said the anemometer was not used in the sewer in testing that question, but in a small box placed over the ventilating shaft in the street, and preventing the passage of all air except through the instrument, or on the rain-water spout. A number of observations had been taken, and there was no question that in the large majority of cases there was a current down from the streets and up the rain-water spouts. That this was often reversed by the action of local currents was quite true; but the reverse process was always the result of an external cause, and when the air was still the current would certainly be down the low-cast and up the up-cast shaft.

Mr. ALTY (Barrow-in-Furness) would like to know whether the President thought that the revolving cowls placed on the upper ends of these shafts were of any use. For his part, he thought they were of no use at all.

The PRESIDENT said the only revolving cowls used as sewer ventilators in Liverpool were on shafts attached to court drains, and were erected before his time. There was no doubt that on the average they did increase the upward current to a perceptible extent. They did not, however, always prevent down currents. But revolving cowls differed from each other. He had made a large number of experiments on the subject, and had at last found a cowl which gave better results than any he had previously used. It was found by a process of experiment and alteration from one to the other. The principal alteration was that the screw was taken out altogether. It was a mistaken notion to suppose that the screw increased the upward draught. It was not the screw: it was the centrifugal and wedge-like action of the slanting vanes upon the rising column of air. He had found that the taking out of the screw lightened the cowl, diminished the friction, and altogether gave a better result than was obtained with it.

Mr. ALTY said he asked the question because he had seen a report recently in which all cowls were condemned.

The PRESIDENT said he had also seen the report, but he would not go quite so far as that.

Mr. PRITCHARD (Vice-President) said his experience had rather led him to the opinion that the system of ventilating sewers by connecting them with rain-water pipes was an obsolete one. He wanted to know whether rain-water pipes connected with sewers or branch sewers acted efficiently at all times, or whether in times of rainfall, when they were required for another purpose than that of up-cast shafts for ventilation, they were not rendered useless for the latter purpose by the discharge of water down them.

Mr. JONES wished to know whether the whole of the rain-water pipes in Liverpool were connected with the sewers, or whether the forty-seven water-spouts per mile were put there for the purpose of ventilating the manholes or shafts.

The PRESIDENT in answer to Mr. Pritchard, said he had no doubt that during storms of rain the current was reversed, and he had no objection to its being reversed. He thought if they could make a storm of rain produce a current in a sewer and blow a great quantity of sewer air out through the carriage-way gratings, it was a very good thing. There were not many rain-water spouts connected with the sewers in Liverpool previous to 1873, but he had connected as many as he could during the progress of the work.

Mr. THORBURN (Birkenhead) said perhaps the President would state if there were any special means taken in connecting rain-water spouts with the sewers to make the joints air-tight, or if the ordinary pipes, just as they were found, were connected with the sewers without any trapping.

The PRESIDENT said they could not always make the cast-iron joints of water-spouts perfectly air-tight, and there was, in his opinion, great objection to connecting rain-water pipes with sewers that were not ventilated, but he could see no such objection when they were thoroughly ventilated. The smell in Liverpool sewers which were ventilated was exceedingly slight. The difference that ventilation had made was something he was not at all prepared for, and he did not think that any ordinary rain-water spout, unless very near to a bedroom window, would be in the slightest degree objectionable owing to its being used as a sewer ventilator. He thought it would if the sewers were not otherwise ventilated.

Mr. ELLICE-CLARK (Hove) asked whether the President attached any importance to the weight of Portland cement, as a test of strength.

The PRESIDENT replied in the affirmative. He added, however, that the test of weight scarcely appeared to be a necessary one, for the cement was heavy by reason of certain qualities, and it was easier to test those qualities than to test the weight. This was the reason why he did not test Portland cement by its weight. Generally speaking, the heavier weighted cement was the best, but it was most difficult to obtain accurately the weight per unit of volume of all finely granulated materials.

Mr. CLARK asked whether the President had made any observations with reference to mixing Portland cement with sea water and with fresh water, and whether he had found that sea water made the cement any harder.

The PRESIDENT said he had not, but several other experimenters had, and had found that Portland cement was stronger when it was mixed with sea water than when mixed with fresh.

Mr. MORANT (Leeds) remarked that from what was said about purging, it would seem that it was not advisable to use Portland cement too fresh, and he remembered an incident which occurred a few years ago, which bore this out. A plasterer went to a cement-factory and bought some cement which had been ground directly into a cart, and with this cement he cast the pillars and bases of some columns. He went the following day to see how they were getting on, and found them in thousands of fragments—burst all to pieces. Experiments were made, and from that time they used to let the cement run on to an open floor to cool and then put it into casks afterwards.

The PRESIDENT said it was absolutely necessary. Portland cement was the most dangerous material they could use if not thoroughly purged, but if thoroughly purged it was the safest. But a manufacturer who simply let Portland cement run out of the machines into the carts, did not know his business.

Mr. WHITE (Oxford) asked if Portland cement could be safely used directly it came from the manufacturer, whether he ran it into casks or not. Should it not be subjected to a further cooling process.

The PRESIDENT replied that it should, unless they had a clerk of the works to see that it was turned over—placed on a large floor, exposed to the air and turned over many times in a week or a fortnight. They had in the paper the specification he now used, and since the paper was written he had seen good reason for raising the standard. He said :—

"Immediately before any special means of testing Portland cement were adopted in Liverpool, the cement used by the Corporation, and supplied by a most respectable firm, gave a strength seven days after mixing of 300 to 400 lbs. per $2\frac{1}{4}$ square inches with the A block. The specification at present adopted by the author (see Appendix I., p. 37) requires the tensile strength to be not less than 800 lbs. with the block B. The actual strength of the cement obtained during the last year under this specification has averaged 871 lbs., and since the tests were instituted the price paid for it by the Corporation has been considerably decreased." That was to say it had risen from 300 lbs. to 871 lbs.

Mr. WOOD: It is considerably higher now—over 1000 lbs.

The PRESIDENT: So that it has risen from 300 lbs. to over 1000 lbs., without our paying anything more. It was simply the effect of competition and testing.

Mr. MORANT (Leeds) inquired whether the water which came from the Bootle well was quite clear, or whether it was impregnated with sand.

The PRESIDENT: It is perfectly clear.

Mr. MORANT said a gentleman present told him that at Warrington where they pumped from the red sandstone, the water was so cloudy they could not see through it in a bath, and he told the gentleman that his recollection was that the water at Green Lane was quite clear.

The PRESIDENT: As clear as crystal.

Mr. PRITCHARD (Vice-President) would like to know the quantity of water obtained from the Bootle well, whether it had decreased of late years, and whether the decrease was considerable or not? He had heard a great deal in connection with the supply from Bootle, and he thought it was a matter of the greatest possible interest to engineers to learn something of the water supply of the new red sandstone from which Liverpool had during many years obtained a very considerable portion of its supply.

The PRESIDENT said that for the last twelve months they had had an opportunity of judging of the question of decrease with more accuracy than usual, by reason of the fact that they had maintained the water at a level in the heading. Previously, they just pumped what they wanted, without regard to the water level; now, they kept it uniformly level, and by doing this they were able to observe exactly any change which took place in the delivery, for the real yield of a well was of course the yield at some constant

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level. If they diminished the level of the water, it was true the quantity of water pumped might be increased, but the yield of the well was not increased on that account. The true yield of the well was the yield at some constant level. Having maintained that constant level, they found that the yield of the well had considerably diminished during the last twelve months.

Mr. Richards: How hard is the Bootle water?

The President: It is about 24 degrees, Clark's process.

Mr. Richards: Have you any scheme in the future for reducing the hardness?

The President: Only by mixing it with more of the Rivington water.

Mr. Proctor (Bolton) asked, Would the President say what percentage he considered the decrease to be?

The President said it varied very much; he should not like to commit himself to a percentage. It was about 140,000 gallons a day, and the present yield of the well was 1,500,000 to 1,600,000.

Mr. Proctor explained that his reason for asking the question was, that he thought it might be worth the consideration of those who were sinking these wells whether they should continue expending money in doing so if the decrease was great.

The President: The question has been very thoroughly before the Liverpool Corporation on many occasions. They are simply sinking one hole now—a bore-hole—to make a great experiment. As the bore-hole is not completed, and engines are not put down, and pumping has not commenced, he did not desire to speak about it. He had simply stated the facts with respect to the existing Bootle well for the past twelve months.

Mr. Pritchard (Vice-President): Is it not a fact that red sandstone wells are being closed in Liverpool in consequence of pollution?

The President: Many wells which were pure at one time, but which are now being impregnated with salt water, are being closed for the purposes for which they were originally used; and there are public wells which have been closed on account of pollution. The first class of wells I speak of as having been impregnated with salt water are chiefly private wells.

Mr. Proctor asked whether any of Jennings' closets were used in Liverpool; and if so, whether the flush was sufficient to cleanse them?

The President: The flush is unlimited.

Mr. Proctor thought it was limited to two gallons.

The President: That is the minimum. It is unlimited, provided the cistern is so arranged that a continuous flow cannot take place.

Mr. Newman (Ryde): What is the greatest the self-closing taps have to bear—the greatest head?

The President: I should think about 90 lbs. to the square inch—about 210 feet. Those self-closing taps are only certain public taps in the courts. We have no self-closing taps in the houses; we do not require them at all.

Mr. Morant (Leeds) asked whether the reducing valves were fixed adjoining the hydrants.

The President: They are fixed on the 4-inch and 6-inch mains, and close to the waste-water meters.

Mr. Morant: You say when the hydrant is open they are thrown out of action?

The President: Even though the hydrant is situated a long way from the valve. The valve is so set that for ordinary purposes it will remain in action, but when the velocity of water is abnormally increased, as it is when a fire takes place, it is thrown out of action, and the full available pressure is obtained at once.

Mr. Pritchard (Vice-President) said he thought Mr. Deacon's waste-water meter ought not to pass without some little comment. Liverpool had been instanced in many places as having overcome the great difficulty in reducing waste. It had been done in a remarkable manner, and the 670,000 people who were supplied with water had been enabled to have a continuous supply, except, he presumed, in case of accident, instead of the very unsatisfactory intermittent supply; and there had been a gain to the Corporation in giving the constant supply. Much must be due, he thought, to the meter which they had so clearly explained to them by Mr. Deacon in that room some three years ago. It must be a very great advantage to a town to substitute a constant supply for an intermittent one. Would the President kindly give them the cost of the ordinary meter which he found most desirable for the purpose of arresting waste.

The President: I have nothing whatever to do with the sale of the meter or with the company which constructs the meter. I cannot answer the question exactly; therefore, I think I had better not answer it at all. The Corporation construct their own meters.

Mr. Pritchard: Can you give us the cost of them?

The President: I cannot exactly, but I believe the market price is about 30*l.* for a 4-inch meter; anybody can get full particulars of it by applying to the makers—the Waste-water Meter Company, Limited, 4, Cook Street, Liverpool.

The first day's proceedings concluded with a cordial vote of thanks to the Chairman for his very valuable paper.

THE ANNUAL DINNER.

At the close of the first day's proceedings, the Members of the Association and their friends dined together.

The chair was occupied by Mr. G. F. Deacon, M. Inst. C.E., Borough and Water Engineer of Liverpool, President of the Association.

Dessert having been placed on the table,

The President said he did not know that he could wish anything more for the future prosperity of this country than he did in wishing that which he was about to propose should be a toast to the end of time in all assemblages of that kind. He gave them 'The Queen."

The President next proposed "The Prince and Princess of Wales, and the rest of the Royal Family." They had all seen recently how thoroughly the Prince of Wales had the vital interests of this country at heart. They knew how at the Paris Exhibition he had entered into the matters which were most intimately connected with the trade and prosperity of this country. The Princess had endeared herself to all their hearts by her many virtues; and the rest of the Royal Family had in their several spheres done everything that could be expected of them.

The President called upon Mr. E. Pritchard (Vice-President) to propose the next toast.

Mr. Pritchard said the toast which he had the honour to propose was one which he was sure would meet with a very hearty response. In every scientific association there was a class of members who stood very much in the same relation to the association as the rudder to the ship. He referred to the Past Presidents. He had the honour of proposing the toast of "the retiring President of the Association." Mr. Ashmead had, during the past twelve months, endeared himself to the Members of the Association by the manner in which he had performed the duties of President, and by the remarkable self-denial which it must frequently have cost him to visit every town where its meetings had been held. He had the greatest possible pleasure in proposing the health of their Past-

President, Mr. Ashmead; and he hoped that he might be long spared to give them his able assistance as a Past-President.

Mr. Ashmead, in responding, said he considered that he had only done his duty to the Association by attending its meetings. He believed he had attended all that had been held, and he could only say that it had afforded him unmixed pleasure. The cordial reception he had met with at every place they had visited had been very gratifying.

The President said there was one toast which they never omitted on these occasions, and it was a toast which if they were to omit they would certainly be very ungrateful. It was "The Municipal Institutions of the Country." To the municipal institutions of this country they owed their special being. He regretted very much that the Mayor of Liverpool had unexpectedly and at the last moment been prevented attending the dinner. Of course, if the Mayor had been present, upon his worship would have devolved the duty of replying. As it was, he would ask Dr. Gill, the chairman of the Health Committee of the Town Council, to reply. If Dr. Gill had not been called upon to reply to this toast, he would assuredly have been called upon as chairman of the Health Committee.

Dr. Gill said he rose with great pleasure to respond to the toast; nevertheless he regretted the cause of his having to do so, namely, the absence of their worthy chief magistrate. As professional men, he was sure they all fully appreciated the assistance which they had derived from the municipal institutions of the country since they were first established. None of them could have visited the large towns of this country during the last quarter of a century without noticing particularly their increased beauty, and the improvement which had taken place in their sanitary arrangements during that period. Before he sat down, if they would allow him, he would propose a toast which he was quite satisfied would meet with the general approbation of the company. It was "The Association of Municipal and Sanitary Engineers and Surveyors." He really did not know what would be done without our Engineers and Surveyors. We were in a great measure dependent upon them for the preservation of our health and for much of the comfort we enjoyed. Being chairman of the Health Commiette of the Liverpool Town Council, he had had many opportunities of judging of the engineering capacity of Mr. Deacon, and he felt satisfied that if any gentleman who had been in the habit of visiting Liverpool in former years would go through it now, he must see a very marked change. The improvement which has taken place in the sanitary arrangements was very great; nevertheless, there was still a great deal to do. As they were all aware, carrying out improvements cost money, and the authorities were frequently crippled and hindered from carrying out their views by the fear of overburdening the ratepayers. There were a great number of improvements that ought to be effected in Liverpool, such as the opening out of the crowded parts of the town and the pulling down of bad property—property that was really not fit to exist on the face of the earth. If they could not only pull down such property, but leave the space open for ventilation, he felt quite satisfied that the town, although it had heretofore had a very bad character, would be very materially amended, as he hoped it would be. He gave "The Association of Municipal and Sanitary Engineers and Surveyors," associating with the toast the name of Mr. Charles Jones.

The Hon. Secretary (Mr. C. Jones), in responding, said that as one who had had to do with the Association since its formation, he could only say that they had had a difficult work to do; a work requiring a vast amount of self-denial, and involving a considerable amount of danger, a work requiring almost night and day application. They were bound together as an Association for mutual help, and it had been said that to a certain extent the Association had been a means of training the younger members of the profession. If so, he was glad. If it should be the means of leading some of the younger members to more decided and daily application in thinking out the several details connected with their duty, then there would be reason to rejoice that it had been formed. It was only five years old, but it had got out of its leading-strings. It had been the means of bringing together, from all parts of the country, men who esteemed one another highly, but who perhaps would never have heard of one another if the Association had not been formed. He rejoiced at the associations and friendships which it had enabled him to form. But there were more important advantages connected with it. There was the influence it exercised on the various towns and neighbourhoods with which its members were connected. They did not meet merely to pass a friendly hour, but for the purpose of gathering information, not for themselves alone, but that they might make use of it for the benefit of the districts where they were engaged. He remembered the time when some of them appealed again and again to the

Local Government Board on various matters, and the answer they met with was: "Your arguments are perfectly sound and true: you are perfectly correct, but you are no body; you have no weight and influence because you are disintegrated. You are not bound together in any way." Their reply was: "Well, we will become a concrete mass;" and they had combined together and become a power—not a power offensive, but a power which, with the knowledge it acquired all over the country, should exercise its influence in support of various measures for the benefit of the country. Where they found such men as Mr. Robert Rawlinson, and others well known throughout the country, helping them, encouraging them, and strengthening their hands—when they found such a man as Mr. Robert Rawlinson, Principal Engineer to the Public Health Department, taking the trouble to write a paper which he sent down, as he could not attend himself, to be read at the last meeting at Wolverhampton—a paper full of terse and excellent remarks bearing on the training and duty of the younger members of the profession, he thought they might congratulate themselves on the position they held as an Association of Municipal and Sanitary Engineers and Surveyors, and he regretted that they were not very much wiser and the Association much larger. One of their disadvantages was, that being officials, their time was not their own, and they could not go hither and thither as they pleased, as non-officials in their profession could do; and therefore they could not always gather together in such numbers as was desirable. Nevertheless, he was glad to see so many gathered together on this occasion; and he trusted that as the Association became known far and wide, it would gather in from north, south, east, and west, men who would strive to help them as they had striven to help each other, and so increase the power of the Association in its work of doing good.

The President said the next toast he had to propose was the toast of the representative body of their profession, "The Institute of Civil Engineers." They were honoured that evening, and he thought they had not generally been so honoured, by the presence of a Member of the Council of that Institute. They all, as Engineers, and as Sanitary Engineers especially, had a great many prejudices to overcome, the prejudice of ignorance above all others; and they must always remember the words of a great man who said that though the pride of science might be great, it was nothing compared with the pride of ignorance. Theirs was a scientific profession, and if they followed it up thoroughly it demanded of them not only the application of science, but the study of abstract science. Their profession was represented by several great bodies in the country, but the more practical branches were chiefly represented by the Institute of Civil Engineers. Many of them belonged to that Institution: he wished he could say they all did in one form or another. It was one of the oldest scientific institutions of any kind in the country. The great names of those who founded it were household names amongst them—Telford and many others; and they had present with them that evening a gentleman whom he hoped they should see among its future Presidents, following in the steps of the great men who had passed away. He begged to couple with the toast the name of Mr. Lyster.

Mr. G. F. LYSTER, M. Inst. C.E. (Engineer to the Mersey Docks and Harbour Board), thanked the Association for the honour they had done the Institute of Civil Engineers by including this toast in their programme, and he thanked the President for the very high honour he had done him, not only in asking him to respond, but in asking him in words of such kindness and words so undeserved by him. The Institute of Civil Engineers needed no words of eulogy or praise from him. Its position was well known and thoroughly appreciated by most, if not all, of the gentlemen whom he saw around him, and he felt sure that not only the profession but the world at large were indebted to the Council of the Institute for the manner in which they had carried out the great duties appertaining to them. Personally, he was not an alarmist, but he had had the opportunity lately of talking with many of the prominent Members of that Institution, who were of opinion that engineers had come to the fringe of their work, and had nearly completed it. He believed they had not, but that, though they might have no startling instances of progress, such as the development of steam or the projection of railways all over the country; still in the bosom of science there were secrets to be wormed out by engineers and applied by them to the future improvement and happiness of mankind. Of that he felt perfectly certain. He would not detain them longer, but he was sure they would believe him when he said how glad he was to meet them; and if in his humble way he could be of any service in showing them any of the important works he had in hand—for they really were very important and quite worthy of their attention, he should be very happy to do so. Their worthy President had mentioned in parenthesis, almost underlined, that he (Mr. Lyster) had not hitherto given that personal attention which he ought to have done to the very important meetings of the Association. He granted it.

The PRESIDENT: I did not say that.

Dr. GILL: It was understood, I think.

Mr. LYSTER said he was not his own master. He had a great deal to do, and if he once dropped a stitch, he had great difficulty in picking it up again. But for that, he should be happy to attend the meetings, and he hoped to make amends in the future.

Mr. ELLICE-CLARK (Hove) said, in obedience to the command of the President he rose to propose the toast of "The Medical Officers of Health and the Various Sanitary Authorities of the Country." He would much rather that some one much more experienced in the work which Medical Officers of Health had done for this country had been asked to propose this toast, more especially as it was coupled with the name of the Medical Officer of Health of the important borough of Liverpool, Dr. Taylor; and he supposed, and he believed it was true, that in no town in the kingdom had the difficulties been so great and so grave as they had been in Liverpool. Most of those present, who were nearly all Englishmen, knew the character of the population and the difficulties with which the Liverpool health authorities had had to contend, and they were no doubt aware of the extraordinary spirit that they had exhibited in grappling with those difficulties. The various volumes that had been issued by them from time to time had quite taken a place in the sanitary literature of the country. And not only had the Corporation of Liverpool, as the Sanitary Authority, been ably assisted and their work furthered by their late Medical Officer of Health, but Dr. Taylor had taken up the lines which he believed he was right in saying Dr. Trench had laid down to ameliorate the sanitary condition of Liverpool. The difficulties he supposed were not less now than they were thirty years ago. No doubt by the various local Acts which the Liverpool people had obtained, and by the large works—sewerage works and other works—which they had carried out, they had succeeded in lowering the death-rate of this great city; but the difficulties appeared to be so great that they still, unfortunately, saw Liverpool nearly always in the unenviable position of having the highest death-rate in the country. It could not be from a want of energy on the part of the Corporation, or a want of energy on the part of their officials. They had from time to time carried out great improvements, and they still continued to do so, as was patent to everybody who knew Liverpool a few years ago. He himself left it in 1860, and had only returned that day, and he saw that vast improvements had been made. Large sums of money, time, and labour, had been spent in doing great good for the people, but there was no doubt that, as had been shadowed forth by a previous speaker, an immense work remained to be done. Whether the Corporation, under Dr Taylor's guidance, would be successful in solving the problem of how to reduce not only the number of inhabitants to the square acre, but the death-rate, and what he believed they would agree with him in saying was equally important, the disease-rate of the city—whether they would be able, by clearing away their streets and by increasing the area of the open spaces, not only to accomplish these great and good results, but whether they would be able, as most Liverpool men seemed to be able to do, to "make it pay," was a matter that the whole country, London not excepted, was watching with the greatest interest. In Birmingham, and in Wolverhampton and other towns, as well as in London, they were attempting to apply the Artisans' Dwellings Act. He said "attempting" to apply advisedly. That was the sanitary nut of the age. They had accomplished in Liverpool admirable sewage works, and they had accomplished, with their immensely increasing population, at all events a fairly successful supply of water. In many other towns, such as Glasgow and other places, they had given a first-rate supply of water. In Liverpool they had accomplished, if he might be pardoned for digressing for a moment, those great engineering works the docks. They had accomplished all these great works, but it was indeed a very trying question for corporations, and a very difficult one for their officers, whether it was possible under any circumstances, without increasing the burden of the ratepayers to a very large, and in some towns an almost unbearable extent, to clear away the awful places which they had heard described by a medical gentleman who was so well acquainted with them. The Liverpool people had no doubt the largest ground to work upon. Dr. Taylor had a field which he believed no other man, certainly in England,—he was going to say on the face of the earth, had to work upon. He was sure that Municipal and Sanitary Engineers always received from the various Medical Officers of Health the greatest assistance. Without them, at times, they would be at a complete standstill in preparing their reports, and they owed to them a debt of gratitude. He thought they were a little jealous in seeing in the last Act of Parliament the extreme of protection thrown over the Medical Officer of Health and the Sanitary Inspector; still they were grateful for this, that almost for the first time in public health measures they saw a first-class professional man fastened on many Sanitary Authorities who were not anxious to have him. The establishment of Medical Officers of Health by the Public Health Act of 1875 had done a great deal to raise the status of Sanitary Engineers. He begged to give them "The Medical Officers of Health and the various Sanitary Authorities of the Country," coupled with the health of Dr. Taylor, Medical Officer of Health for Liverpool.

Dr. Taylor responded. He thanked the company, in the first place, on behalf of the Medical Officers of Health in general, for the great compliment which had been paid to them; and he did not know that such a compliment could in any way be more enhanced than by the knowledge that it came from a body of gentlemen with whom they were so intimately associated as the Municipal Engineers, for whatever credit or success Medical Officers had achieved, it had been achieved in great measure by the assistance of Municipal Engineers. Whatever researches Medical Officers of Health might have to carry out, or whatever means they might have to take in preventing epidemics or stemming them in their course, they must in a great measure depend on the assistance and co-operation of the Engineers; and he therefore said that no greater compliment could be paid to the Medical Officers of Health than to have such a kindly and sympathetic expression of feeling towards them as had been given by the gentleman who had proposed the toast. For himself, he thanked them very sincerely for the way in which his name had been coupled with the toast. He felt that he had a great deal before him. He knew that he had a great many difficulties to encounter, and he knew that he followed in the footsteps of two gentlemen who had been highly honoured, and to whom he feared he could not be equal. The difficulties with which the Officer of Health in Liverpool had to contend were various. In the first place, the old structural arrangements were of a very imperfect and of a very unfortunate character. Various Acts of Parliament had been obtained, but those Acts of Parliament, like most others, were prospective in their operation, and the evils which they saw when those Acts were obtained still continued to exist. The operation of the very first Act obtained was to clear out 3000 cellars in the borough of Liverpool. But Liverpool being proximate to Ireland, had unfortunately been a rendezvous for the poor of that country. When the Irish famine occurred no fewer than 300,000 Irish paupers landed on their shores, and from 70,000 to 80,000 permanently took up their residence, and, no provision being made for them, the cellars which had been cleared out were taken possession of by these poor unfortunate creatures; and every Paddy brought with him the thing he cherished—his pig. It was years before the authorities could get over this, and before they had well got the town clear of this misfortune they had the cotton famine on them in 1864. They had the poor vagrants and unemployed from the manufacturing districts pouring in, and they had an epidemic of typhus. This continued until 1866, when cholera visited the town. Such a series of misfortunes it was difficult for any town to encounter. They fought with them, battled with them, and endeavoured to obtain various Acts of Parliament to assist them. They worked strenuously, and he was glad to say that Liverpool was not the most unhealthy town in England, for there was one town, which he did not wish to name, whose death-rate exceeded that of Liverpool; and he hoped that before his course was run he should be able to place Liverpool in a far better position than it at present occupied. Whether he succeeded or not, he should feel that he had the proud consciousness of having saved the lives of a number of innocent creatures and lessened the miseries of a still greater number; and, whatever the world might say of him, he should feel in his own mind that he had endeavoured to discharge his duty as an honest man.

Mr. Lyster said he was sure the company would cordially accept what he had got to say if he suggested that the time had arrived when they should propose the health of their worthy President. He thought it was all-important that the position of the President should be thoroughly recognised. He had had the honour and pleasure of knowing Mr. Deacon for some years, since he had been in Liverpool, and he had had a great many professional relations with him, and, though it was hardly fair to say to a man's face what one thought of him, he considered he was perfectly justified in saying that he had never met with anyone in a more agreeable way, or been more cordially met in public matters, than he had been by their President. He thought the town of

Liverpool was to be congratulated on having the services of a man of Mr. Deacon's professional acquirements, and from what he knew of the schemes propounded by Mr. Deacon for providing the town with a copious supply of that very essential element, pure water, he felt quite certain that the town of Liverpool would soon wipe away the reproach of unhealthiness, and any faults of that description. He had had the pleasure of going over the plans of Mr. Deacon's, with the Chairman of the Water Committee, Mr. Wilson, and, as far as his humble opinion went, he thought the scheme was worthy of the support of every member of the community. He gave them, with all the honours, "The Health of the President."

The toast was received with enthusiasm.

The PRESIDENT, in responding, said he could find no words to express the thanks he owed to them for the kind manner in which they had drunk his health. Mr. Lyster had referred to several matters in connection with his position—with the work he was doing for the Liverpool Corporation; but the matter which concerned him most intimately at the present time was the work he was doing in connection with the Association of Sanitary Engineers. He could only say that he would endeavour, so far as lay in his power—his power in this respect was to some extent limited by the time he could bestow on other matters than the work of the Corporation, but he would endeavour, with that limitation, to follow in the footsteps of their retiring President, Mr. Ashmead. He could give them no better assurance of his wish to do his best for the Association than that.

Mr. R. VAWSER (Hon. Secretary, Lancashire and Cheshire) said the toast that had been entrusted to him was one which he was sure they would receive with enthusiasm. It was, "The Health of the Vice-Presidents of the Association." When the Association was first instituted, they were content with one Vice-President, and Mr. Lemon filled that office with great credit to himself and with satisfaction to the whole of the Members; but after a time, as it was found that the Members were spread over such a large district that it was impossible for one President, even with the assistance of a Vice-President, to supervise, as it were, the whole working of the Association and to keep in communication with the whole of the Members, it was thought prudent to divide the responsibility amongst a greater number, and, accordingly, they now elected three Vice-Presidents. Those who held the office at present were

Mr. Morant, Engineer to the Corporation of Leeds; Mr. Fowler, Engineer to the Corporation of Newcastle-on-Tyne; and Mr. Pritchard, who held an important appointment in the Midland Counties. The whole of these gentlemen had been connected with the Association from the first, and they had all been hard workers for the Association and had rendered very great service to it. In fact if it had not been for their efforts, he believed the Association would not have been in existence at present. They were amongst the pioneers of the Association, and they deserved all credit for the position which it occupied. They also represented the largest towns in the United Kingdom. One did not like to say much to their faces, but they really did deserve everything that could be said about them. There was one thing that probably they would bear in mind—that in due course they would probably arrive at the rank of President. He hoped that when they did, they would fill the chair in the same creditable manner as Mr. Ashmead, and that when their term of office expired and they retired into private life, they would carry with them the good wishes of the whole of the Members.

Mr. Morant, in returning thanks on behalf of himself and Mr. Fowler, who was absent, said he could only say that he had from the beginning taken a very great interest in the well-being of the Association. He was one who took part in its formation. At that time there was an idea of starting a Society for mutual protection, and to defend themselves against attacks. He set himself against that, but he thought that an Association, such as this was, for the purpose of meeting each other and comparing notes, was of very great importance, and he could only say that, as one of the older members of the profession, he should at all times be happy to afford any assistance to those of his juniors who might wish at any time to consult him.

Mr. Pritchard next responded. He said there were certain difficult duties which even Vice-Presidents had to perform, and he was sure they would not be found wanting when called upon to perform those duties. Although they had had an excellent President in their past President, Mr. Ashmead, he felt satisfied that the choice they had made of a successor augured very well for the future success of the Association. He was pleased to hear Mr. Deacon spoken so highly of by so eminent a member of the Civil Engineering profession as Mr. Lyster; and for his own part, he could only say that during his year of office it should be his earnest endeavour to further the interests of the Association as a Vice-President, and to give to the President all the assistance it was possible for him to give.

Mr. Thorburn (Birkenhead) said the toast which he was deputed to propose was one which he was sure would meet with their hearty sympathies; and when he told them that it was "The Hon. Secretary and the Local District Secretaries," they would see at once that they were the working bees of the hive of the Association. He was sure that the secretaries they had had for some years—Mr. Jones, the Hon. Secretary of the Association; Mr. Pritchard, the Secretary when it was first formed; Mr. Vawser, who formed the District of Lancashire and Cheshire; and Mr. Boulnois, the North and South Wales and Devonshire and Cornwall District—had all worked very hard to promote the welfare of the Association. Mr. Ellice-Clark had taken charge of the Home Counties, a very important district as they were aware, and he had always been to the front in promoting the interests of the Association. These gentlemen were the backbone of the Association. Without their assistance it would become a disintegrated mass, instead of being a concrete body, working together for mutual instruction—more especially for the instruction of the younger Members of the Association—and for the benefit of the community they had the honour to serve.

Mr. Vawser having been called upon to respond, said he had great pleasure in doing so, although, properly speaking, there were many Officers of the Association who had been longer connected with it than he had who ought by rights to have responded. Mr. Jones, on whom the whole work of the Association in the main depended, and who was one of the original promoters of the Association, deserved a very great deal indeed for what he had done. The provincial officials endeavoured to do the best they could, and to a certain extent, he dared say, a good deal rested with them; but their work was of very small importance compared with that of the executive in London. There was a good deal of labour usually required of the Local Secretary in anticipation of their annual meetings, and the present was the second time that he had had the honour of officiating in that capacity, the previous occasion being a similar meeting in Manchester three or four years ago. At the meeting in Manchester he was very largely aided by Mr. Lynde, who held the office of President last year; and on the present occasion he was happy to say that Mr. Deacon had taken a large share of the work. In fact, his (Mr. Vawser's) duties had been a sinecure, and Mr. Deacon, who had worked hard and taken an active interest in the welfare of the Association, had kindly seen to many of the local details which properly belonged to the Local Secretary's department. He could not possibly accept the whole of the honour of the arrangements which had been made for the meeting in Liverpool, without doing justice to Mr. Deacon in that particular.

The Hon. Secretary (Mr. C. Jones) proposed "The Press," which was responded to by Mr. E. H. Edwards ('Liverpool Mercury'), after which the company separated.

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SECOND DAY'S PROCEEDINGS.

Friday, July 26, 1878.

The Second Day's Meeting was held in the Council Chamber, Town Hall, Liverpool, Mr. G. F. Deacon, President, in the Chair.

The Proceedings commenced with a paper on

COURT AND CELLAR DWELLINGS IN LIVERPOOL.

By J. STOPFORD TAYLOR, M.D., Medical Officer of Health for the Borough of Liverpool.

The location of the labouring classes in our large cities and towns has not only engaged the attention of philanthropists and sanitarians, but special consideration has been given to the subject by our Government, who have endeavoured, by the Labourers' Dwellings Act of 1868 and the Artisans' Dwellings Act of 1875, not only to provide for the future accommodation of the working classes, but have included in their measures various methods for abolishing the wretched courts and alleys, which are a disgrace to our present civilization and a constant menace to the public health. The difficulties in carrying out the two Acts of Parliament arise from the local peculiarities of different towns, as in the various classes of people for whom provision has to be made, the character and situation of the business in which they are employed, and the great cost incurred in obtaining possession of the property. In Liverpool we have had considerable experience of these difficulties, and in considering what would be the best course to adopt for the future, and wishing to avoid the mistakes of the past, I have thought it desirable to bring under your notice the past and present condition of our courts and cellars, and the proceedings that have been taken to render them less injurious to the physical and moral condition of the inhabitants.

According to the census of 1841 the parish of Liverpool contained a population of 222,542, and the out-townships, 63,484. In the parish there were 1982 courts, containing 10,622 houses and 55,534 inhabitants.

The following is a description of the courts given before the Health of Towns Commission: "They consist usually of two rows of houses, placed opposite to each other, with an intervening space of from 6 to 13 feet, and having two to six or eight houses in each row. The court communicates with the street by a passage or archway 3 feet wide—in the older courts built up overhead, and the farther end being also closed by a high wall or the back of an adjoining building, thus forming a *cul-de-sac* with a narrow opening, and what little air could gain admission was contaminated by the exhalations from the common privy and ashpit, placed either near the entrance or at the end of the court. The houses are three stories high, containing three rooms about 10 or 11 feet square, and built back to back with houses of an adjoining court; most of the houses have cellars, and many are let off as separate dwellings." There were upwards of 8000 inhabited cellars, and the occupants were estimated to be from 35,000 to 40,000. "The cellars are described as 10 to 12 feet square, generally flagged, but frequently having only the bare earth for a floor, and sometimes less than 6 feet in height. There is frequently no window, so that light and air can only obtain access by the door, the top of which is often not higher than the level of the street." Such were the dwellings of one-half of the labouring classes forty years ago; and I regret to state that, notwithstanding the exertions of the Corporation and the lavish expenditure of money, many of the evils still continue, and by fully exposing those evils can we alone expect to have them removed.

Previous to 1842 streets were laid out and houses were built to suit the pecuniary benefit of the owners; not a single thought was given to public health, which for some time past had suffered considerably, and the constant prevalence of fever began to create alarm. The Corporation now obtained their first sanitary Act, "The Health of the Town Bill," 1842, which, amongst other valuable provisions, enacts that opposite rows of houses shall not be built where there is a carriage-way, except they are separated by a street 24 feet wide, and where there is no carriage-way, by a space of 15 feet. All windows are to be made to open, and all cellars are to have 2 feet of their height above the level of the adjoining ground, but the provision as to cellars was not to come into force until July 1st, 1844, when about 3000 were closed as not complying with the Act.

The year 1845 was marked by an epidemic of dysentery, and the Corporation, perceiving the melancholy condition of the public health, which clearly arose from the insanitary state of the town, as pointed out by Dr. Duncan, obtained, in 1846, the most important sanitary Act that had hitherto been passed by Parliament. By this Act all streets or carriage-ways were to be 30 feet wide, all courts were to be 15 feet wide, with an entrance of the same width, and if containing more than eight houses an additional width of one foot for every such additional house. No court cellars were to be let as separate dwellings, and all cellars in streets intended to be let as separate dwellings were for the future to be built 7 feet high, and not having more than 4 feet below the surface of the foot-walk; there were other provisions with respect to areas, windows, &c., but all these measures, with the exception of that relating to court cellars, were of a prospective character, the cellars which complied with the Act of 1842 being specially exempt. Notwithstanding the limited powers conferred by this Act and the Act of 1842, it was estimated in 1851, that above 8000 cellars in the borough (which now included the out-townships), containing a population of 30,000 individuals, were closed as separate dwellings, but it required the constant attention of the health officers to prevent them being re-occupied.

Previous to this Act there was no power to put the lodging-houses under any official supervision, the consequence was that overcrowding of the most vicious and degrading character prevailed, more particularly in courts and narrow streets, presenting scenes of wretchedness almost indescribable. Bye-laws were now made for the better regulation and supervision of these places; and the register of March 31st, 1851, records 659 lodging-houses registered to accommodate 5627 lodgers, though application had been made for permission to lodge 8533 persons in them. This was a most important and requisite course for the Corporation to adopt, but the evil of overcrowding had become of such magnitude that future measures were required to which I shall afterwards allude.

Liverpool at this time was thoroughly a privy town, for there were but few water-closets, and these drained into cesspools. The injurious effect of the accumulations of human excreta adjacent to the dwellings of the people was well understood by the Health Committee, who, in their programme of what was essential to improve the public health, included the abolition of privies and cesspools and the erection of water-closets.

In 1854, the Corporation obtained the "Liverpool Sanitary Amendment Act," which contains that important provision under which the conversion of privies into water-closets has been effected; and in no cases has it been more beneficial than in changing the common court middens into trough water-closets. The provision is as follows:—"That when and so often as it shall be certified to the Council by the Medical Officer of Health, under his hand, that any privy, drain, or cesspool is in a condition, state, or situation injurious, dangerous, or prejudicial to the health of any of the inhabitants of the borough, it shall be lawful for the Council, if they think fit, to require the owner thereof, by notice in writing for that purpose, signed by the Town Clerk, forthwith or within such reasonable time as shall be specified in such notice, effectually to abate and remedy the same in such manner so as to avoid any injury, danger, or prejudice to the health of any inhabitant." The remedy suggested by the Corporation has been the erection of a water-closet instead of the privy, and the public now fully appreciate the advantage to health and comfort by the change.

In 1861, typhus began to increase and soon assumed an epidemic character, spreading its ravages to every part of the town. The public demanded further sanitary measures, and the Corporation obtained the Sanitary Amendment Act of 1864. This Act did not interfere with cellars, but left them under previous regulations, whilst some very important provisions were included with respect to courts. Courts were now to be built of the width of 15 feet, open at both ends of the full width of the court into public streets, or otherwise of a width including the entrance of 25 feet. At this time the Corporation also passed bye-laws under the Local Government Act of 1858, regulating the amount of open space to be left at the rear or side of every new dwelling-house; for a one-story house, 10 feet; for two stories, 15 feet; for three stories, 20 feet; and for a house of four stories, 25 feet, measuring from the house to the opposite property.

The effect of these bye-laws in conjunction with the new laws respecting the width of courts has been to prevent the erection of court houses, and the very beneficial change resulting from these powers can only be fully appreciated by comparing the houses erected for the working classes before and after the passing of these laws.

The most important provision of the Act of 1864 is that which refers to improving the ventilation of existing courts, and states that "If the medical officer of health shall find that any court or alley or any premises is or are unfit for human habitation, or in a condition, state, or situation injurious, dangerous, or prejudicial to health, he should report the same, and that the powers of this Act ought to be put in force in respect to such court, alley, or premises, and whether the ascertained defects can be remedied by structural alterations and improvements or otherwise, or whether such court, alley, or premises, or any or what part thereof, ought to be demolished."

In accordance with this provision, the late medical officer, Dr. Trench, made five presentments, recommending structural alterations and demolition of many houses in a large number of courts, by which a very beneficial change was effected, and the character of the courts improved; but in carrying out the Act the expense was found to be very great, far greater than it ought to have been, for in most of the cases it was really improving private property at the public cost, and to avoid the legal charges, which the owner could put the Corporation to, from 60 to 70 per cent. more was given for the property than it was worth. The amount expended for this purpose was 90,000*l.*, and to lessen the cost of converting court middens into trough water-closets, the Corporation contributed for draining, flagging, &c., 37,000*l.*, making the total cost so far for improving court property 127,000*l.* Another question may be fairly asked, Who has derived the greatest benefit by this large expenditure of money? Certainly not the public who have to find it, for whatever sanitary advantages have been obtained, they are more than counterbalanced by the wretched and dilapidated condition into which the houses have fallen, and the consequent degradation and demoralization of the inhabitants. No doubt much may be said on behalf of the owners of this class of property, that the condition of the people depends greatly upon their own conduct, yet it cannot be controverted that of persons living in the middle of insanitary surroundings, such as may be found in hundreds of courts in this town, their physical condition reacts on their moral condition, and has a great effect on the physical and moral condition of their children, and whatever advantage and instruction children may derive from attending school is in a great measure neutralized by the bad effects of the evils and dirt and filth which they see around them at their homes. That the children are weakly and delicate can well be understood, and the continuance of these evils will perpetuate a race deficient in mental and physical health, and only fit for the workhouses and gaols. There are courts where all the houses are so dilapidated that the owners have closed them; others have some of the houses unfit for human habitation, and which have not been occupied for years, and into houses that have been closed by order of the magistrates, openings have been made and they are now receptacles for filth. It is perfectly useless to attempt patching up any such property, the only satisfactory way to deal with it is by demolition, but how it is to be done is the problem we have to solve. By the Labourers' Dwellings Act of 1868, there is to my mind a very clear and efficient remedy; it places the duty upon the owners either to demolish or make such structural alterations as may be necessary at their own cost; but for some reason, which I cannot well understand, there is a strong objection to putting this Act in force. It surely cannot be that the owners have a prescriptive right to injure the health of the community, or that the property has not paid for itself over and over again, by producing a net rental, which it did for many years, of 10 to 12 per cent.; and now that the life of the property is exhausted, are the public to pay the owners a premium to do what is their duty?

The better class of workmen have long removed from these miserable abodes, and the present class of tenants are as wretched as the tenements they occupy; they appear quite satisfied and contented, and do not evince the slightest desire to alter or improve their condition, and the owners may well complain of the damage done by them, and the difficulty of obtaining sufficient rent to pay the expenses; but what else can be expected? for it is only such unfortunate people who would occupy such dwellings.

The difficulty in dealing with court property under the Artisans' Dwellings Act of 1875 arises from the impossibility of providing accommodation for the people in the immediate neighbourhood of the property from which they are displaced. Nor is it desirable that such large numbers of the people should dwell in parts of the town where the air is polluted by manufactories, and ventilation impeded by high buildings. The Act is being carried out at Nash Grove, where an area of 4 acres has been cleared of dwellings, and the result of this experiment will influence our decision as to the desirability of extending its operation to other parts of the town.

The action of the Common Lodging House Act has been more beneficial in lessening overcrowding in court houses and cellars, for, as previously observed, there was no limitation of numbers occupying a house previous to the Act of 1846, whilst at the present time there are on the register 1046 lodging-houses, affording a space of 300 cubic feet for each lodger in the bedroom, besides the use of a sitting-room during the day. Some of the houses are fitted up by private individuals, and called model lodging-houses for working men; they are on the whole well managed, and a very great improvement upon the ordinary lodging-houses. During last May thirty-six model houses were inspected three days consecutively, and though licensed to accommodate 2935 men, only an average of 2000 were found in them, and there was no cause of complaint. A system prevails here to a very great extent termed sub-letting, where more than one family occupies a house, and is a great cause of overcrowding. The Corporation have made regulations under the Sanitary Act of 1866 for registering sublet houses where single rooms are occupied by day and night, and the space required for each adult is 350 cubic feet; the number of such houses on the register is 12,041. The better class of houses in which apartments are let and where there is no fear of overcrowding are not put on the register. One quarter of our whole population is thus provided for, and will afford an illustration of the amount of supervision required on the part of the Health Committee to preserve the public health. By this system of registration and enforcement of regulations (about twenty cases for the violation of them are taken before the magistrates every week), and the abundant supply of houses in the out-townships, there are fewer applicants for the court houses and cellars, and their value is rapidly declining.

There are now in the borough 2700 courts of all kinds, many of which have been erected since the Act of 1846, and are fairly good; others may be improved by removing houses which contract or narrow the entrances; but a large number cannot be made fit for human habitation, and ought to be demolished.

The Corporation have applied for a Provisional Order for this purpose, and the matter is still under consideration; it is proposed that where a house is in itself not defective, but where its demolition would improve the adjoining property, the Corporation should pay its full value; and where the property is in itself bad and cannot be improved, then the Corporation should pay the value of the materials and site, or the owner can elect to retain the site. The legal machinery for this purpose is considered satisfactory by our Town Clerk, and it will be a great boon to the town when it is obtained.

After the passing of the Act of 1846 a general inspection and measurement of the cellars was made, and a list prepared of 14,166, of which a record is kept; since then many more have been built under the Act, and it would be giving a low estimate to state that there are 20,000 cellars with which the Sanitary Authority has to deal. About one-half of them are occupied as separate dwellings, and the remainder for the most part are receptacles for filth, and a constant trouble to the owners and inspectors. The Corporation are now taking steps to close the cellars, which, though legal by the Acts of 1842 and 1846, are illegal by our Improvement Act of 1871 and the Public Health Act of 1875; and they are also prepared, on the consent of the owners, to fill up the cellars with clean soil or cinders from manufactories and flag over the areas. A large number will still be left for human habitation; and this burrowing in the ground will, I am afraid, continue unless in an amended Public Health Bill the occupation of all such dwellings is prohibited.

Such is a brief outline of the proceedings taken in respect of cellar and court dwellings in Liverpool. The gradual movement of the people from the parish into the out-townships lessens very considerably the probability of increasing the miseries of the poor by clearing away a large mass of insanitary property; and as it always will be necessary that a body of workmen should reside in the centre of the town near their employment, so it is incumbent on the authorities that the air around their homes should, as far as practicable, be free from pollution. Why not add to this obligation the providing of open spaces near their dwellings, "veritable oases in the desert," where the children could play and the adults assemble after their daily labour, instead of crowding the corners of the public streets? and this could readily be effected by apportioning sites after the dilapidated courts have been removed.

DISCUSSION.

The PRESIDENT said they had now heard the paper which Dr. Taylor had with so much trouble laid before them. The duties of Medical Officers of Health and of Sanitary Engineers were distinguished, as he thought, by a very fine line, although a very graduated line; that was to say, they interlocked into one another in a way which rendered it impossible for either to proceed satisfactorily with his work without understanding something of the work of the other.

Mr. LEMON (Southampton) said he had no doubt it was a matter of surprise to all of them to find such a number of persons still living in the courts of Liverpool. At the same time, he thought they must all appreciate the energetic steps which had been taken by the Corporation of Liverpool to remove the occupants. In reference to the last Act of Parliament which was referred to by Dr. Taylor, he thought one of the difficulties in carrying out the Act was that they were asked to provide accommodation for the persons removed in the same vicinity, or rather, they were asked to put the same number of persons on the same area. Now, he thought that was a great defect in the Act. He thought it would be very much better if that provision were thrown out altogether, and if it were treated really as an improvement scheme. A scheme for the improvement of the streets should go hand in hand with a scheme for the improvement of dwellings. He knew cases in which it was impossible to provide for the same number of persons, and he was rather surprised at the way in which it was attempted to be carried out in London. The Home Secretary was rather severe on that point. He said: "You are not giving that provision for the working population that you ought to do." He (Mr. Lemon) thought that that should be disregarded, and that the thing should be dealt with as a whole. When a scheme of that kind was to be carried out they should look at it as for the improvement of a whole city rather than for the improvement of a particular locality. He was rather surprised that the authorities had not done more in reference to closing these cellar dwellings in Liverpool, because they were illegal under the Public Health Act, 1875. He had no doubt there were great difficulties, but at the same time he thought they had the powers if they would put them in force.

Mr. Ashmead (Past President) said that perhaps some Members there, like himself, had no cellar dwellings in their towns. He did not know of a single cellar that was occupied in Bristol.

Mr. Parry (Reading) asked Dr. Taylor what had been his experience with respect to extending the system of water-closets in courts. They were generally, he believed, found to be nuisances as soon as they were put into small properties. He knew they had been found so in cases he had a knowledge of in Reading. They were doing away there with the old cesspools, and it was gradually becoming a water-closet town the same as Liverpool. Where they did away with the old closets and cesspools they were endeavouring in every way to establish water-closets; but in the courts they became greater nuisances. They could not keep them clean.

Mr. Morant (Vice-President) said they were endeavouring in Leeds to get rid of the difficulty of putting water-closets in poor neighbourhoods by putting trough water-closets, which he thought were used in Liverpool first. They were not found to be any nuisance.

The President: Are they of the same type as in Liverpool?

Mr. Morant: Yes.

The President: Made of earthenware?

Mr. Morant: All glazed fire-clay; and they are attended to every day, or every other day—cleaned out.

Mr. Angell (Past President) said that, as had just been remarked, the state of things in Liverpool was so unique, so quite beyond the experience of Borough Engineers elsewhere that one was hardly prepared to offer any remarks, excepting to express great surprise that such a condition of things had existed at all. There were at the present time 20,000 cellars in Liverpool, half of which were occupied. It was a state of things which, without understanding the local difficulties, he said should be immediately abolished, under the provisions of the Public Health Act. The paper had been rather interesting as showing the historic part of the duties of the Medical Officer in Liverpool; but it seemed rather like reading of the ancient lake dwellings in Switzerland, of something past and gone, of archæological interest, than of something existing in the present day. He could only express his surprise at such a state of things existing, and his hope that it would be speedily abolished.

Reference was made in the paper to the width of courts, and a distinction was made as to carriage-ways and courts. Of course, it was necessary to have carriage-ways a certain width for carriages to pass, but they were dealing with sanitary operations, and he found 15 feet courts in Liverpool. That was a state of things which he did not think was permitted under the Public Health Act.

Dr. Taylor: That is open at both ends.

Mr. Angell said the district he represented would not allow such a thing as a 15-feet court. Under no circumstances did they allow anything under 40 feet wide. He only knew of two exceptions in the last eight years, and in those instances the width was 20 feet. Of course, land was very valuable in Liverpool; but there was no reason why working men should not live outside and have cheap trains and other means to bring them in to their work rather than crowd wholesale in the centre of the town. As representing the Sanitary Engineers of this country, he expressed the hope that this state of things would be speedily abolished in Liverpool.

Mr. Ellice-Clark said he thought that if Mr. Angell and many others who lived in the south of England and had done so for many years, had seen the state of things in Liverpool, they would have come to the same conclusion that Dr. Taylor and the Corporation had. The difficulties the Liverpool people had had to contend with seemed to him to have been enormous, and to his mind there was not any sanitary body in the kingdom which had attempted to grapple with its difficulties with the same spirit of earnestness that the Liverpool Corporation had shown. Even young as he was, he remembered having lived in Liverpool thirteen years ago and seen the dreadful condition of things, as a lad, that had been so graphically described by Dr. Taylor; but when they heard, as they heard the previous evening from Dr. Taylor, that 70,000 of the low, poor, and ignorant Irish at one time, and within a very short period of time, took up their abode in the town of Liverpool, they could very readily understand that it was quite impossible that these people could have found anything like adequate accommodation in the existing houses. Another great difficulty that would always exist in Liverpool, and in all seaport towns, was that the labourer must be near his work. The occupation of most of the labourers in Liverpool and other seaport towns was not like the fixed occupation in other towns, where the workmen went to his work at a certain time, and left it at a certain time. In a manufacturing town a man could have half an hour to go to his work by tramway; but in Liverpool it was tidal work, and the workman must be near his work, and he should think that was one of the great difficulties to be contended with in Liverpool. To his mind, Liverpool seemed to have spread out in the last twenty years more in proportion than any other town in England. The population no doubt was exceedingly dense, and perhaps more dense, in proportion to the reasons he had stated, than most other towns; but he did not think it was possible that the working population could ever be provided for outside a certain area, within a certain distance of the docks. He supposed the reason that the Corporation had not insisted on wider streets was the great difficulty that, if they had, they would simply have turned the people out-of-doors. There would have been nowhere for them to live. He was very glad to hear Dr. Taylor speak of the water-closet system as he did, and of its having been a success in Liverpool, for if the water-closet system could be introduced amongst the class of population which lived in these cellars and courts, it could be introduced anywhere. They were constantly hearing from their brother engineers and surveyors that water carriage could not be applied to manufacturing populations, but he thought Liverpool afforded a striking instance of water-closets system having been successfully applied amongst, if one might use the term, the most demoralised kind of population; and he thought that, if the Sanitary Authorities of many of the Lancashire towns would only take the lesson of Liverpool to heart and apply water carriage properly to certain portions of the town, first as an experiment, they would very soon see the filthy, abominable system of cesspools and middens, and the still more abominable system of tub closets existing and growing all round Lancashire and Yorkshire, abolished. He was in hopes that at this gathering they would have had a paper comparing water carriage with the tub system. He saw that Mr. Hewson was going to read a paper. He had not had the pleasure of seeing it in print, but he thought that many of the members from the South of England would be glad to know the arguments on sanitary grounds which he would bring forward to show why the solid intercepting systems should be still perpetuated as against water carriage.

Mr. Pritchard (Vice-President) said that, having resided in Liverpool many years ago, he could fully corroborate what had fallen from Mr. Ellice-Clark in reference to the vast improvement that had taken place in Liverpool; and he thought that the paper, which Mr. Angell had declared to be a very interesting one, also showed the vast works that had been undertaken and completed in connection with the town. The difficulties were great, very great, and when their respected Past President referred to West Ham, a large district near to London, and, in fact, by many called a suburb of London, where the space between the houses was 40 feet, they knew that that was very desirable; still, if Mr. Angell would look in the City of London itself, he would find courts existing there with a very small space between the houses.

Mr. Angell: Pardon me, I was referring to the new regulations.

Mr. Pritchard said the difficulties, no doubt, in Liverpool had been immense, but the excellent paper Dr. Taylor had submitted showed that not only had certain improvements been made, but that certain other improvements were to be made. The Corporation of Liverpool, he took it, intended making Liverpool in a sanitary sense as healthy a place as it was possible to make it. Dr. Taylor had alluded, not in his paper, but in his remarks at the dinner, to the great and unusual difficulties the Corporation had had to contend with in connection with the immigration from Ireland during the famine, and from various parts of Lancashire and Yorkshire during the cotton famine. That, he thought, should explain that all could not be done that was desired to be done, but he hoped to see Liverpool in a very short time not in the unenviable position of being one of the large towns with the greatest death-rate, but equal in healthiness to the other large towns in the country. He saw present Mr. Till, of Birmingham, who, he had no doubt, could give them very good information in reference to the cellars of that important place. It was very desirable that cellars should be removed, although he scarcely agreed with Dr. Taylor that they should be filled with cinders. He thought they should be filled with something less absorbent than cinders. If Dr. Taylor had suggested that they should be filled with sand, and that connections should be made so as to take away the water, he should have thought it more desirable. The paper, to his mind, was not only interesting, but very instructive as to what could be done by a Corporation dealing with a very difficult subject.

Mr. Till: I was not in the room during the reading of the paper, but we have no cellar dwellings, I should say, in Birmingham.

Mr. LEMON (Past President) said he should like to ask Dr. Taylor how it was that the Corporation had not closed buildings that were unfit for human habitation, as they had the power under the Act to do. In Southampton they had not only the same power under the Act as Liverpool had, but they had a special byelaw under which any building unfit for human habitation could be closed. Of course it could be reopened again on the certificate of the Medical Officer when the owner had made the necessary alterations. The effect of putting this power into force had been to shut up all buildings unfit for human habitation, and he should like to ask Dr. Taylor how it was the Liverpool Corporation had not put it in force.

Mr. PARRY (Reading) asked if Dr. Taylor would also explain how those two Acts worked together—the 1864 Act, which enabled Corporations to agree to courts only 15 feet wide, and the Local Government Act, enabling them to make wider streets and give proper area and open space between the houses. They seemed to him to clash one with the other, without some special explanation.

Dr. TAYLOR, in replying, said that perhaps before he referred to each question separately he might be permitted to state that in Liverpool there was a large mass of unskilled labour. The nature of the occupation was such that the temptation was great for people to come here from the country districts. From all parts of England, from Wales, from Scotland, and even from Ireland, they came to Liverpool to find employment amongst the unskilled labour, the wages being of such a tempting character that the labour market was generally overstocked in that respect, independent of what occurred in exceptional periods; so that they could well understand that previous to the great access of population in 1847 Liverpool was overcrowded, and then when they had 70,000 people forced on them the authorities were entirely unprepared for them, and had been in difficulties ever since in providing accommodation for them. The reason why they had not closed the cellars in Liverpool has been simply because they had not had the power. It would be recollected that in his paper he said that the first Act of 1842 stated that all cellars were to be closed which had not 2 feet above the surface of the adjoining footwalk, and the Act of 1846, in prescribing that the space above the surface should be 3 feet and 4 feet, specially exempted and legalised the existing cellars which had only 2 feet above the footwalk. This continued until 1871, when an Improvement Act was obtained, in which there was a clause making those cellars illegal which had less than 3 feet above the surface of the footwalk. There had been some difficulty, owing to overcrowding, in carrying out this Act fully. It was being carried out gradually; if it were carried out fully perhaps 20,000 people would be put into the streets without any home. Acts framed on the Act of 1846 corresponded so closely with the Public Health Act of 1875 that there was little or no difference between them, and those cellars of course would continue in occupation. There was no power to close them. He might state that when the Corporation first began removing middens from courts they tried syphon closets, but they were immediately found not to answer; trough closets were substituted, and no difficulty whatever was found with them. Since 1860 no houses—not even workmen's dwellings—had been built without water-closets; no privy had been allowed to be built. The only complaints about water-closets in Liverpool were from the owners of property who had to convert privies into water-closets; there were no complaints from the owners of fresh houses who were required to attach water-closets to them. He had mentioned the class of population with which the Liverpool authorities had to deal. It was really a very great difficulty, and the only way he could conceive of introducing an alteration in the habits and manners of that class of people was by gradually destroying bad property. Wherever they had a miserable class of property they were sure to find a miserable class of tenants seeking a home in it. His own opinion was that it was necessary to put, as it were, a degree of compulsion on these people. They were compelled to send their children to school; why should they not be compelled to cleanse themselves and keep their houses in order? Such restrictions should be placed upon them that they would be obliged to seek better quarters. Mr. Lemon asked why more houses unfit for human habitation had not been closed. The health officers were frequently taking the owners of such houses before the magistrates, who ordered that the houses should be rendered fit or not occupied. In many cases the owners would repair the houses, and they became reoccupied. There were other cases where the houses were in such a condition that they were not worth the expense, and they remained unoccupied. Then what action could be taken? The door was locked, but the windows were all broken, and perhaps part of the roof off. But though they were in such a dilapidated condition, the officers had no power to interfere unless they could go before the magistrates and prove that the houses were a nuisance to the neighbourhood; and they would all well understand what a difficulty there was in proving that to the magistrates. In a great number of cases they had proved them to be nuisances, and got the magistrates' order to close the houses, that was, to brick up the doors and windows. There was a great deal of property in Liverpool the owners of which could not be found to do any work, but there was no doubt that if the Corporation was going to take possession of the property they would soon be found. In those cases the Corporation had built up the doors and windows, so as to prevent a nuisance being committed, yet holes had been made through the bricks and people had thrown their ashes and rubbish in, and waifs and strays had got into the houses and used them as domiciles. What was wanted where places got into this dilapidated condition, degrading to the surrounding people, was an easy and ready means of obtaining possession of this property, so that it could be demolished.

Mr. Angell said the meeting would be aware that Dr. Taylor came amongst them as a visitor, and not as a Member of the Association; therefore, he had very great pleasure in proposing a vote of thanks to him for his interesting paper. They were always glad to see Medical Officers amongst them because their line ran very much together, and they were of great and valuable assistance in directing the works of the Engineer.

Mr. Dunscombe (Derby) had much pleasure in seconding the vote of thanks.

The President said he had also much pleasure in putting it to the meeting, and he was quite sure there would be no dissentient voice.

The proposition was carried unanimously.

The President said he thought there must have been some misapprehension as to the Act with respect to the width of courts. It was 15 feet, open at both ends; but that was not a carriage-way. No carriage-way could be made less than 30 feet wide; so that the fact was that there were no new courts. There were only four or five cases of new courts having been built in Liverpool, because people would not now build houses to which there was no carriage-way approach.

Mr. Lemon remarked that in Southampton they passed a bye-law that there should be no court of less than 20 feet width, and the result was that there had been no application to build courts.

Dr. Taylor, in acknowledging the vote of thanks, said it had been a very great pleasure to him to come amongst them. It was by the friction of minds and opinions that they hoped to advance their views, and be of use to their various constituents.

THE GEOLOGY OF LIVERPOOL IN RELATION TO ENGINEERING WORK.

By T. MELLARD READE, C.E., F.G.S., F.R.I.B.A.

In response to a request conveyed to me by Mr. G. F. Deacon, our Borough Engineer, I purpose to lay before you an outline of the geological structure of the country about Liverpool, as it is disclosed by and affects engineering work.

To enable a stranger, and especially one not very familiar with the technicalities of field geology, to realise my description, we may imagine a boring to be made at the point A, on the accompanying plan, near the mouth of the River Alt. The succession of strata would be as follows:—

1. Blown sand.
2. Peat, and the remains of an ancient forest, with the roots of trees *in situ* below the level of high water.
3. Laminated blue clay, gradually shading off into sandy silt, and containing remains of marine shells—named by me Formby and Leasowe Marine beds.
4. Boulder clay. A stiff brown clay, evidently a marine deposit, and containing more or less travelled stones, many of them planed and striated, and bearing evidences of ice action. Alternate beds of clay and sand might be met with and gravel at the base.
5. Red or yellow sand, evidently ground from the basement rock, and seldom containing anything but fragments of the basement rock, or a travelled boulder, half embedded in it and half in the clay.
6. Red or yellow rock, some member of the Trias, probably the lower Keuper Sandstone, similar to what is seen in the Little Crosby quarry. If the boring were continued very deep, it would probably pass through the Upper Bunter, the Pebble Beds, and the Lower Bunter; below this we need not concern ourselves with the geological structure, as the underlying beds have no outcrop about Liverpool.

If the boring had been more to the north of the point selected, we should have penetrated, after the boulder clay and before the lower Keuper sandstone was reached, a great thickness of Keuper Marls, similar to the salt-bearing marls of Cheshire.

My knowledge of these various strata has been acquired from the examination, for many years, of excavations which have been made from time to time for engineering works and the foundations of houses.

Post-Glacial Beds.

It will, then, be seen that there exist three distinctive groups of strata.

First.—Nos. 1, 2, and 3, containing occasionally other and marine beds which occur associated with or intercalated in those described, but in other localities. They are shown on my large vertical section. This group is quite distinct from all the strata below, and can be unfailingly recognised on a very short acquaintance. It is called the "Post-glacial" series, as being posterior to the boulder clay, which is a glacial marine deposit.

The large map, 6 inches to the mile, shows the whole area of the deposit which fringes the margin of the south-west coast of Lancashire, and the north-west coast of Cheshire. The map is the result of several years' close observation and inquiry on my part, and is put together from the records of various borings and examinations which I have either made, seen, or obtained. In no other way could the true nature of the ground have been discovered, as these strata are quite horizontal, and no outcrops are to be seen such as assist the geologist in mapping rocks.

In Lancashire these deposits, as shown, occupy an area of about 75 square miles; in Cheshire, 7½ square miles.

To an engineer these recent strata perhaps possess more special interest than any of the others, from the difficulty he experiences in getting good foundations for his work upon them. Above the Peat and Forest bed in various inlets and gullies in the coast lie deposits of recent silt, not unlike, nay, frequently undistinguishable from, No. 3. In these beds many of our dock works have been executed.

The site of the old dock, now occupied by the Custom House, is an instance, as it was constructed at the mouth of a gully called the "Pool," which ran along the course of Paradise Street, Whitechapel, and Byrom Street. The foundations of the Midland warehouse in Victoria Street and Whitechapel disclosed a section of this Pool, which is described by Mr. Isaac Roberts, F.G.S., in the Proceedings of the Geological Society of Liverpool.*

Quite recently I came upon the bed of the Pool, higher up, in the foundations of an addition to Messrs. Cook and Townshend's shop, Byrom Street.

The Birkenhead Docks, which are constructed upon the site of the old Tranmere Pool, disclosed the same sections, and the failure of the entrance wall was caused by the foundation not being carried through it to the boulder clay. This blue silt is extremely troublesome, and in some cases runs almost like water. For instance, at the Truant Industrial Schools of the Liverpool School Board at Hightown, I sank an Abyssinian tube well through 17 feet of blown sand and 2 feet of peaty soil to a depth of 29 feet below the surface, and the mixture pumped up was more than half composed of extremely fine, silty sand.

In carrying out the Birkdale Outfall Sewer, the blue silt caused me much trouble and anxiety, as it was very difficult, in fact almost impossible, to keep the timbering of the trenches straight and vertical. Pipes 2 feet 6 inches diameter were fractured along the top by the superincumbent pressure, and eventually a brick culvert embedded in concrete had to be resorted to.

Whenever there is an inlet to the river or estuary, such as a stream of water has formed, there we may be sure to find the blue silt and peat in some form or other. Thus at Seaforth Station, on the course of the Rimrose, the peat is 40 feet thick with silt under it. At the mouth on the shore, the Peat and Forest bed was formerly to be seen, and the north wall of the Dock Estate disclosed some of the deposit. The very extensive excavations at the north docks, now being made under the superintendence of our Dock Engineer, Mr. Lyster, have disclosed fine sections of this silt, boulder clay, sand and gravel, and Triassic rock, commonly known as New Red Sandstone. The same exposures took place at the Garston Dock excavations, of which I exhibit sections. The foundations of the Leasowe embankment is also on this series of deposits; indeed, wherever we go round our coasts, the hydraulic engineer in most estuaries has to contend with a similar series of deposits, showing that it is not a local but general formation. I have seen it at Newport, Monmouthshire, in the new dock constructed by Mr. Abernethy; it was met with at Holyhead, in the harbour works at Swansea, on the course of the old river, and in the Hull

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* December 17, 1872.

Docks, as described by Mr. Hawkshaw, the engineer, in the 'Quarterly Journal of Geology.'

Before leaving this division of my subject, I may say that the blown sand, which covers 22 square miles of the Lancashire coast, is very troublesome to construct sewers in. Building operations are extending rapidly at Crosby, and other places along the coast; and it has been my lot to carry out a great many miles of sewers in purely blown sand. Fireclay socketed tubes are mostly used; the trenches require very close piling, and it is extremely difficult to get proper cement joints made, especially at the invert, from the reaming in of the running sand. The sand, so difficult to deal with in foundations which go below the subsoil water-level, makes a good and firm foundation when not penetrated so far. I have erected a great number of houses upon the blown sand, with three courses of footings, without concrete, as a base; and in some cases these structures have been erected on the top of a levelled sand-hill: yet so incompressible are these grains of silex, that I have had only one instance in which anything like a failure took place. London architects, I know, would be surprised to hear this, as they seem to consider concrete essential in all such places.

In the foundations of the Truant Schools at Hightown, where I had to go below the subsoil water-line, I had wooden frames made the width of the footings, and filled them *in situ* with cement concrete, the materials being put in dry, and mixed with the water in the trench. This method succeeded very well, as there have been as yet no signs of settlement.

Boulder Clay and Drift Sand.

It is quite evident that the Boulder Clay, or Drift Sands and gravels, have covered the whole of the country in this neighbourhood. From some of the more prominent places, such as the high ground at the Parish Church of Walton-on-the-Hill, parts of the village of Much Woolton, at Rainhill, and Farnworth, and in the neighbourhood of Ormskirk, Melling, Aughton, and Lydiate, the Boulder Clay, or Drift deposits, have been removed by denudation. A careful study of these deposits has convinced me that they once formed the floor of the seas that swept over these islands during the glacial period. I have identified *forty-four* species of shells, some of them of a boreal character, the typical shell being *Astarte borealis*, and found now no further south than Kiel, in the Baltic.

Intermixed with these northern shells, I have found *Cytherea chione*, a Spanish and southern form.

Sprinkled throughout these deposits are large erratics of granite, greenstone, volcanic ash, and other stones not found *in situ* nearer than the Lake District or North Wales. One of these stones I lately measured in the north dock excavations was 7 feet by 5 feet by 4 feet. Many of these large blocks are planed and striated, and have evidently once been set in the bottom of a glacier, then broken off as an iceberg, and floated to their present locations. Not only are the large stones striated, but some of the smallest pebbles, the size of a nut, are also. The mountain limestone boulders retain the scratches very perfectly. Of 100 boulders I counted at a brickfield at Great Crosby, forty-seven, or nearly half, were more or less striated.

The quantity of the stones comparatively to the clay matrix varies considerably, and the stones are a great trouble to the brickmakers, especially the limestone pebbles, which get calcined in the burning, and afterwards absorbing water burst the bricks.

The thickness of these Drift deposits varies from nothing to about 140 feet, the deepest I know being in the old bed of the River Mersey, under the town of Widnes.

Many geologists separate the Drift into three divisions, viz., the Upper Boulder Clay, Middle Drift sand and gravel, and Lower Boulder Clay; but I look upon them all as one great deposit, with local variations, and am very dubious of the correlation of these different beds in various localities. I think, however, we may venture to say that, as a rule, the lower beds of clay, when they occur as distinctive beds, are stonier, contain more boulders than the upper clay, and fewer large erratics. Near the north docks this stony clay appears to graduate into gravel, which fills up deep gullies, cut into the sandstone rock. This bed of gravel has been quite a godsend for the formation of concrete for the dock works, of which a large quantity has been used for backing for the walls.

The neighbourhood is deficient in a natural supply of shingle, most of that used in Liverpool coming from abroad as ballast. The bulk of the clay is of a more plastic character than the foregoing, and is often separated from the lower beds by a line of denudation and a thin seam of stratified sand; but it is very difficult to lay down any general rule for the geological interpretation of the deposits.

It is very singular in excavating in the town of Liverpool to come upon these relics of a period of floating ice. This I exhibit is a chipping from a glaciated erratic of porphyritic felstone, which was found in the excavation at the corner of Victoria Street, where it had lain embedded at the base of the clay under the cellars of some very old property. Another and larger erratic was found in the same place half embedded in the red sand which often lies on the top of a red rock, between it and the boulder clay above. A still larger greenstone boulder was found in an excavation in Hackins Hey, and they are, in fact, common under the foundations of Liverpool.

As regards engineering works, the pot-holes of sand which exist in the boulder clay give a great deal of trouble in carrying out sewerage works. In Thomas's Lane, Broad Green, a man was killed by the falling in of such a pot-hole, cut through by the sewer excavations, and these pot-holes caused the contractor great trouble and expense. Now, however, the Cheshire Lines Railway crosses the road at the point where one of these pot-holes existed, but their cutting being so much deeper than the sewer excavations drained the sand, and there was no difficulty experienced with it, nor did it apparently interrupt the work in any way. If of reasonable thickness, the boulder clay forms a very good foundation for buildings, but included beds of sand and pot-holes are very troublesome.

This clay has been for a great length of time very extensively used for brickmaking in the neighbourhood. Almost the whole north end of the town has been excavated for this purpose, and in fact everywhere in the outskirts brickfields occur. This is useful, but when the brickmaker has finished then comes the filling up of the excavations with rubbish, and hardly is it accomplished before the Welsh builder runs up streets of houses upon the loose, incoherent materials, with the certain after-effect of walls out of plumb, heads and sills out of level—often broken, crooked gutters and cornices. Nor is such a proceeding beneficial to health, but how to stop it is a difficulty for the solution of which I can offer no suggestion. To return to the bricks, the surface clay is almost universally the best for the purpose, from the fact of it having been exposed so long to atmospheric influences, through which alternate shrinkage and expansion has taken place, the rain percolating into the fissures, and forming those grey and blue joints which so facilitate the getting of the clay. The depth of the clay got out at one time is usually 7 feet, and a brickmaker reckons he should make 1000 bricks to the square yard, but this varies to some extent according to the quantity of the included stones. In some places where bricks are in great demand, and the clay thick, this operation is repeated two or three times. At the North Fort the clay is being burned in rough lumps, as ballast to form concrete with.

To anyone who wishes to see the foregoing series of deposits, I should recommend a visit to the North Dock Works, as the excavations there are over a larger area, and deeper than we generally have an opportunity of seeing.

Surface of the Triassic Rock.

We now, continuing our investigations downwards, come upon the red or yellow rock, and before examining the rock itself it will be instructive to pause to consider its surface configuration. The first and most noticeable feature is that where the rock is hard and has had a covering of boulder clay, we are almost certain to find it planed, grooved, and striated usually in a north-westerly direction. There have been many good examples of this in the neighbourhood of Liverpool on all sides. It is generally supposed by geologists to be the work of an ice sheet, or confluent glacier ice, having the centre from which it has radiated in the mountains of Cumberland and Westmoreland.

But perhaps more interesting than this fact is the disclosure which various excavations and borings have made of the surface configuration of the rock, showing that it was at one time a sub-aerial or land surface, with valleys and gullies and cliffs worn therein, which, upon the subsidence of the land in the glacial marine period, became filled with the drift deposits scattered over the floor of the ocean. Thus there is a rocky valley I have traced by borings following the line of the Mersey from Warrington to below Runcorn, and not passing through Runcorn gap, but under the site of the town of Widnes. Several years ago I inferred from this that the rocky valley followed the line of the river, and that there probably exists a rocky gorge between Liverpool and Birkenhead, through which the waters of the Mersey in pre-glacial times discharged themselves, when the level was relatively to the sea higher than at present. Subsequent investigations have tended to confirm me in this belief, for in the north docks a gully (before mentioned) filled with gravel was cut through for the wall foundations, and not bottomed at 36 feet below Old Dock Sill, nor did an iron rod 12 feet long, driven into the gravel below this, reach the rock, showing that it was at that point more than 48 feet below Old Dock Sill. Farther south the gully was bottomed at 26 feet below Old Dock Sill, proving that it ran northwards and increased in depth rapidly. The inference is that there must be a still deeper gorge in the river, of which it was an affluent. These are singular and interesting facts, of which you can appreciate the bearing in the proposed Mersey Tunnel works.

Triassic Rocks.

These rocks, when reached, of course in all cases terminate our digging for foundations. A word as to their economical aspect. They constitute the whole of the local stone, and many of the beds form very good building stone; but in consequence of its porosity, which makes the rock such a good water-bearing stratum, it is apt to convey the damp into a house. In fact, it should never be used unless backed up with brickwork. The white stone of which Compton House is built is from the Stourton quarries, in Cheshire; and some of the old Liverpool buildings are of similar stone, from equivalent but harder beds in Liverpool, from quarries now closed, and indeed built over. This stone is the Lower Keuper sandstone, and in it at Stourton are the footprints of the *Cheirotherium Stourtonense*, a large labyrinthodon. The stone generally used now from the neighbourhood is that of the pebble beds of the Bunter. Messrs. Wells and Sons' quarry at Bootle supplies a great deal of this rock for the north end dock-works. There is also a fine red stone from the Runcorn quarries, which can be obtained in very large blocks, and is free from pebbles. It belongs to the Keuper division.

My slight sketch must now draw to a close. I have refrained from saying anything on that vexed question, the water-supply from the New Red Sandstone, as my views will be published in the forthcoming report of the British Association. In conclusion, I would commend the study of geology to engineers and architects. As a practical training for the powers of observation and reasoning, I consider it to be as a science unrivalled. It bears on an engineer's work, renders that which is looked upon by the ignorant mind as dirt or "muck," of surpassing interest; it dovetails in with his daily work, and it gives to the world facts that, unnoticed, would be irretrievably lost.

DISCUSSION.

The President said the paper which Mr. Reade had just read showed in an admirable manner how much could be done by any Member of the profession to promote geological knowledge. Mr. Reade, as they knew, was a civil engineer in practice, and he had simply followed up geology as a recreation and study in connection with his work. He fancied that if all the Borough Engineers and Surveyors of this country were to take notes of the strata through which they passed with their works in the same way as Mr. Reade had done, we should have a record of the previous history of England, such as all the speculative geology of the past had failed to give us. Geology would then be raised from the least exact of all the sciences to a simple statement of facts, and the conclusions drawn from those facts would be infinitely more trustworthy than they were at present.

Mr. Roberts (Liverpool) said, Perhaps one or two practical questions would be answered if Mr. Reade would state the depth of the material which caused those pipes to fracture for which he stated he had to substitute brick sewers. He (Mr. Roberts) had found in his own experience that the 12-inch fire-clay pipes gave way under a pressure of earth of about 14 feet. He did not know what was the depth of pressure on the pipes to which Mr. Reade alluded, but this was a matter to be taken into consideration in selecting pipes as the material for work instead of brick. The great thickness of peat to which Mr. Reade had referred, 40 feet, was quite exceptional; and he did not think Mr. Reade would wish them to infer that that peat was a continuous bed which resulted from growth in position, for they had evidence in many parts of peat, such as that found at Leasowe and Seaforth, at the present day, breaking loose from the mass and drifting in considerable blocks along the river. If it found a sheltered place where it could not be drifted, probably it would there sink, and an accumulation of such drifts might account for the great thickness of peat to which he had referred. He believed the area exposed was not large, and it was quite exceptional in the district. Building upon a foundation of sand, as Mr. Reade had pointed out, would be quite safe provided it was uniform over the whole of the building. Some time ago he had occasion to build a warehouse on filled-up material near the docks. The filled-up material was probably 20 feet in thickness, and he simply placed a bed of concrete to distribute the weight of the walls over a large area and then built on the concrete. The only effect detrimental, if such it were considered, was that the warehouse sank a little; but it sank bodily, it did not incline one way or the other, nor did the walls crack. The only other point he would say a word upon was the quality of the bricks in the district. The material of which the bricks were made consisted of the boulder clay which Mr. Reade had described, and in it was a large proportion of limestone. The attempt had frequently been made to mould this clay into bricks by machinery, but it had always failed owing to the presence of the limestone. Machinists, when that was pointed out, said, "Oh, crush them." That appeared a very simple remedy, but the effect was quite the reverse of what they proposed; for if a stone the size of the hand were crushed into a hundred pieces, and a piece however small, if it were only the size of a mustard-seed, got into a brick, the brick would burst, the limestone being converted into lime by being burned and the lime again expanding when water came in contact with it. It did not matter how small a piece of limestone might be in a brick, if water came in contact with it after it was burned into lime, it must burst. Hence, by crushing the limestone the evil was increased, and hence the rough mode of moulding by hand was continued, letting the stone get into the bricks and burst in those into which it happened to get. He was afraid the prospect of improving the quality of bricks in this locality was not a very bright one, and the cost of bringing them from a distance was very great.

Mr. Morant asked the last speaker where the pipes were laid that gave way at a depth of 14 feet, and what make they were. He was in the habit of laying them regularly at that depth and had never known them to break.

Mr. Roberts said there were two pipes, one above the other with a little clay between them, and probably one pipe crushed the other to some extent. Both pipes were found broken.

Mr. Pritchard (Vice-President) said Mr. Reade had told them that he had great difficulty with pipes of a certain size, and that the pipes were fractured. He should like to ask whether the the pipes to which Mr. Reade referred were placed upon an even bed, and whether the bed varied in texture or density. He, like Mr. Morant, was about putting the question as to the make of the pipes. He was about to inquire the make of the pipes, and also whether there was any local circumstances to account for the fracture beyond the superincumbent weight; whether the bed was a firm and even bed throughout, so far as regarded its hardness or its density, and whether the pipes were fractured in the collar or in the spigot. He thought these were important questions at the present time, as so many pipes were being used for purposes of this description. He had placed pipes without concrete on a firm but properly prepared invert to receive them at a depth of 20 to 25 feet, and had not seen any fracture in something like 40 miles at different depths, from 14 feet to as much as from 23 to 24 feet.

Mr. White said he also had used pipes to the depth of 23 and 24 feet and never met with an instance of fracture.

Mr. Morant said Mr Reade had mentioned that in putting in concrete he put in the materials dry, would it not have been better if he had mixed it with water and let it partly set, and then put it in? Would it not have made a better job?

Mr. Lemon (Past President) said he was quite sure that the Association must be very much indebted to Mr. Reade for the great trouble and care he had taken in preparing his very excellent paper. It was a record of the geology of Liverpool which must be not only valuable to the immediate neighbourhood of Liverpool, but valuable to, he might say, the entire kingdom, and he did not think they should allow such a collection of drawings to pass away, as it were, without any notice. He thought the Association ought to take some steps to reproduce such a valuable collection. If it could not be done out of the ordinary funds, it ought to be done by means of a special payment. With regard to the remark of the President that if the Borough Surveyors all over the kingdom were to take notes of the strata through which they passed in their work, the information thus obtained would be of great value, he might say that in the instructions issued to the Local Surveyors by the Local Government Board, they were told to do so, but he did not know whether any did. He was sorry to say that he himself did not, but after the lesson he had received from Mr. Reade he must do so, because a knowledge of geology would teach an engineer to build on a sure foundation. If he had a knowledge of geology he would know of course what was below, and how to so vary his materials and so treat his buildings that he would not have those difficulties with the settlements which sometimes occurred. In one part of England they did not think anything about a building going down 18 inches or 2 feet. That was a very common thing; but they had such a knowledge of the soil on which they had to build that they so disposed their weights that when the building went down it went down equally and did not fracture. For instance, they never stuck a great lump of chimney at one end of a building and a very light structure at the other. They studied weight in their designs and plans, and the result was they did not get those unfortunate settlements. He unfortunately got into a difficulty in that respect not very long ago—only the year before last. He put up a building, and, being unduly weighted, it went down. There was not the slightest fracture, but it was out of the perpendicular and he had to underpin. He thought he should have built it differently if he had given more study to the geological formation on which he had to build. He therefore strongly urged upon engineers and surveyors to study geology, because he was quite sure it would not only give them an immense amount of amusement and information, but would make them much better engineers. He had very much pleasure in proposing a special vote of thanks to Mr. Reade for his great kindness in laying this subject so clearly before the Association, and in expressing, on the part of the Members, the great debt of gratitude which they owed him for the great labour he had gone through.

Mr. Morant, in seconding the proposition, said he agreed with Mr. Lemon that it was very desirable to have Mr. Reade's drawings reduced and published.

The President remarked that the question was under the consideration of the Council.

The vote of thanks having been carried unanimously,

Mr. Reade in acknowledging it, briefly replied on the discussion which had taken place. The depth of the sewers at Birkdale, where the pipes were fractured, was, he said, as near as he could remember, from 14 to 16 feet, and the material in which the pipes were placed was the sand itself, all exactly of the same character as nearly as could be judged, with no stones in it at all; and he confessed that he was very much surprised at the fracture of the pipes, because the nature of the ground approximated more nearly to hydraulic condition, in which pressure was equal on all sides, than was generally found, the weight being generally on the top. He was, therefore, not prepared for the cracking. The crack took place right along the top of the pipe. He went inside the pipe to examine it, and the fracture was certainly not the result of any inequality in the ground—for instance, from the pipe being on a hard foundation in one place, and a soft one in another, which would fracture any pipe. He was rather surprised to hear of a pipe of 12 inches in diameter breaking at a depth of 14 feet, but not so much when he found that one pipe was put over the other, for from experience he knew that one had a tendency to break the other—to produce that unequal pressure which they should all guard against. A few years ago he put down an 18-inch pipe sewer under the railway at Crossby at a depth of from 13 to 14 feet. It was bedded on boulder clay and had all the drains passing over it. He had since had an opportunity, whilst a drain was being constructed, of seeing the pipes, having to go down to them again, and he had found them quite perfect, although the drains had been passing over them for two years. He thanked the Members of the Association most cordially for the way in which they had received his paper, and he could only say that if the Association desired to have the benefit of his plans, they were fully at their service.

This concluded the second day's proceedings.

THIRD DAY'S PROCEEDINGS.

Saturday, July 27, 1878.

The Third Day's Meeting was in the Council Chamber, Town Hall, Liverpool, Mr. G. F. Deacon, President, in the Chair.

The President: I cannot commence the ordinary buisness of the day without saying a few words in reference to the latter part of our work yesterday. Under Mr. Lyster's guidance we have inspected engineering works of greater magnitude than we have hitherto visited elsewhere, and we have all been struck by the unique and admirable manner in which Mr. Lyster has met the increasing difficulty of the day in connection with the state of the labour market. We understood from Mr. Lyster that it was originally intended to employ masonry to a much larger extent than was ultimately thought desirable. Masonry would have involved an amount of hand labour which in the present state of the labour market would be impossible or most difficult to obtain; but Mr. Lyster was equal to the occasion, and we cannot doubt that the modes he has adopted have resulted in an enormous saving of money and increased efficiency. We saw Portland cement concrete employed with little labour where in the old days nothing but masonry would have been thought applicable; and we saw immense iron culverts protected by Portland cement being laid in a tithe of the time in which masonry culverts of equal efficiency could have been constructed. I believe we have to thank the state of the labour market for the admirable improvements which Mr. Lyster has introduced.

ON THE MANUFACTURE OF MANURE FROM TOWN REFUSE.

By THOMAS HEWSON, Borough Surveyor, Rochdale.

The disposal of the refuse of towns it will be allowed is a most troublesome question, and especially to the manufacturing towns of England, not excluding even those having the water-closet system. First and foremost is the petulant cry of the ratepayer, who but for the warnings of the tables of mortality is half disposed to fence in his city with house refuse sown with green but unhappily decayed leaves; and, secondly, there is the harassing complaint, constant care and determination required to systematize the collection, so that there shall be none, or, if any, the minimum of nuisance; and, thirdly, there is the dealing with this raw material when collected, and herein lies the greatest of all the difficulties, for whilst the material is produced in regular well-ascertained quantities it has a demand or market only twice a-year, leaving no refuge to the sorely-tried inspector but to store a commodity in itself dirty, repugnant, perishable, and so nuisance creating.

Speaking generally, the cost of any system of disposal is the measure of value applied to it by town councils, consequently the system which cleanses the least frequently and disposes of the most closely to the town, *being the least expensive*, is unfortunately looked upon with the greatest favour.

General as this rule is, the Rochdale Corporation, and here I must include the ratepayers, have proved themselves an exception to it, for recognising in the old privy and ash-pit system nothing less than a most active nuisance greater than all others put together, and that it was a manufactory of pestilential gases spread so evenly over the whole borough that if all other nuisances were fairly well attended to this would still remain a physical but ironical protestation of the good sanitary government of a borough, it determined, if the pail system answered, gradually (if possible without legal proceedings, but in the end surely) to abolish the old privy system.

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Nine years ago this resolution was come to, but for four or five years afterwards, beyond the privies for new dwelling-houses erected, few of the old privies and ash-pits were altered to the pail system. From that time, however, the voice of the public has enabled the Council to proceed more rapidly, and to-day so few of the old ash-pits and privies remain that the Corporation has decided on being immediately and entirely rid of them. Thus far we have in Rochdale successfully dealt with two of the difficulties before named; the third, that is, the dealing with the material collected, and which, as usual, though the last is the greatest difficulty, is the one to which I more particularly invite your attention.

The cost of the pail system, accompanied by a disposal of the excreta in its crude state, is much more expensive than the old privy system, the income from sales being no more, whilst the cost of collection will be from ten to twenty times as much.

With this knowledge and experience of increased cost the Council have latterly very naturally sympathized with all efforts of the Department to utilize, at a better rate, the proceeds of collection.

On the introduction of the system, the public used also their ash-pail tubs for the reception of house liquid refuse. This prevented proper riddling and sifting; so to enable us to deal with the ashes properly, drying floors with cast plate covers were provided for drying them, but by the more general use of the system the public were soon educated on the subject and we were able to dispense with them.

With this exception, from our first effort we have not discovered any better plan of dealing with the ashes and vegetable and other refuse matter than that of sifting and riddling; burning the cinders and vegetable matter for generating steam, selling the glass, rags, and iron, and using the fine ash for admixture with the excreta.

We have, however, taken to mortar-making, and this finds a secure haven for oyster-shells, &c.

With a view to making a manure by thoroughly saturating house ashes, the Department first tried using ashes in the pails after the manner of the Goux system. This method interfered with the cleansing of the pails, and was found to absorb so little of the urine that to make a portable manure other ashes had to be added to the collected pail contents. As a substitute for the ashes in the pails various disinfectants were then tried, such as common salt, sulphate of iron, and chloride of lime, but finally the plan was adopted of using a liquid disinfectant devised by A. Taylor, consisting mainly of a manufactured chloride of alum and sulphate of lime, and of mixing the pail contents with the necessary quantity of fine ash produced at the works. From the great length of time it took to dry the ash manure naturally, i. e. by lying under sheds in great heaps, drying floors with flues, having brick sides and flag covers, were tried, but it was soon found that the great heat produced a rapid combustion in the manure, destroying the ammonia, and so leaving a weak manure. Recourse was then had again to the plan of natural drying with the aid of sulphuric acid, but under sheds well ventilated and large enough to store a year's collection, and allow the fine ashes to be saturated twice or three times with excreta.

This process was carried on most determinedly for a number of years, the conviction being that concentration, so as to produce a high-class manure, was the only way to obtain a remunerative return for manufacturing a night-soil manure.

With all the efforts thus made, and after using ash two or three times over, a manure worth 30*s.* per ton was the greatest achievement made; the moisture remaining being quite 33 per cent. You will readily see that the cost of carriage limited to a very small area indeed the market for such a low-valued manure as this.

To get out of this difficulty, therefore, recourse was had to the purchase of blood manure to fortify the weaker product of the pail contents. Despite this addition, however, and by the rapidly increasing quantity of collection to be dealt with, the stock increased so enormously, as, unless more sheds were erected, the drying would be interfered with.

At this time, with a view to producing a cheap fortifier for the ash manure, an experiment was tried of evaporating urine by means of a jacketed cistern, but strange as it may appear on the conclusion of this paper, it did not answer.

Evaporation of the pail contents was then tried in the ordinary potter's slipkin, that is, a cistern having earthenware sides and bottom on flues, but this process was so slow as to be altogether out of the question. Evaporation by waste heat from furnaces, boilers, &c., was tried, but this also failed. Indeed so many experiments were tried and failed that the Council, having allowed the Department to run up a capital account of 15,000*l.*, and with a full knowledge that the reported cost of the system for several years depended largely on the value put on the stock determined to manufacture no more manure until the stock was disposed of; and shortly afterwards that the Committee managing the pail system should deal with the whole of the night-soil; it should also manage the remaining old privy system.

These things were done, and the result was that the pail system, which cost 2637*l.*, together with the old privy system, which cost 1919*l.*, total 4556*l.* in 1875, cost in 1876 13,234*l.*, and in 1877 12,635*l.*

In justice to manufacture of the pail contents it is necessary to say that this extra cost was not solely due to the loss of stock, but in addition, first, to the extra cost incurred in disposing of the pail contents in a crude state (for taking into account the labour at the works and freight this could only be done at a great loss); and, secondly, by farmers refusing unriddled ash-privy; and, thirdly, of sifting and dealing with the collections from old privies in a more thorough manner than had been done previously.

Little more than a year of this return to first principles had passed when the Council altered its view as to manufacturing, and consented to the Health Committee making further efforts in that direction. This it did, the result being the adoption of our present process.

This process is that of evaporation by boiling in Firman's drying machines.

This machine was patented principally for the purpose of reducing animal matter, and has arrangements for taking off the oily fat; but a specimen of the animal matter so dried falling into the hands of Mr. Alderman Taylor, it occurred to him that with very slight alterations the machine might be adapted to the drying of excreta, and on his strong recommendation Mr. Firman was invited to fix one of them as an experiment, and on terms.

The result was so very surprising, both as to the evaporating power of the machine and the slight loss of ammonia, that one was ordered, since which another has been obtained, and at the last meeting of the Committee two others were ordered, which are to be stronger built, with duplex arrangements, and having jacketed storage cisterns for utilizing the steam of evaporation.

The machines in work are cylinders 13 feet long and 4 feet diameter, jacketed three parts of their circumference, and fixed on hollow revolving shafts of different diameters, but to which are attached agitators, which may be hollow arms acting also as scrapers.

The space in the jacketing and shafting is charged with steam at only about 30 lbs. pressure at present, but arrangements are being made to work at 60 lbs., it being found that that pressure dries a charge in 3½ hours which at 30 lbs. takes 5½ hours.

The power required is merely that necessary for revolving the axle and agitators, which is not more than two horse-power, a six-horse engine being sufficient for three machines.

The steam used for evaporation is at present produced by a boiler 30 feet × 6 feet, with fire-grate 10 feet × 4 feet at each end, and discharging into the atmosphere by a chimney 40 yards high. This large boiler, fired with cinders, is found too small to afford steam for two machines at 60 lbs. pressure, only producing indeed 20 lbs. pressure. The furnaces and flues are made this size, and specially set to consume large quantities of vegetable garbage, infected clothing, &c., and as, by alternate firing, one fire is always at red-heat, the odours from burning vegetables are destroyed. Since the quantity of steam given off by the evaporation was found so great as to interfere with the furnaces, the steam and effluvia given off by evaporation is drawn through pipes placed in running cold water for condensing, and so much of the steam and effluvia after this treatment as remains is forced by a blower through the boiler furnaces. A charge for one of these machines consists of 47 cwt. of pail contents, to which are added nearly 60 lbs. of sulphuric acid.

This charge, consisting of 83 per cent. of water, is, as before stated, at 30 lbs. pressure in 5½ hours, and at 60 lbs. pressure in 3½ hours, reduced to 4 cwt., with not more than 5 per cent. of water. The work capable of being done by a machine in one day at 30 lbs. pressure we find is two charges of five van-loads of twenty-four pails each; these pails are from 480 houses of four and a half persons each, and as the collection is weekly, this represents a population of, say, 12,960. On the completion of the evaporation a slide door in the bottom of the cylinder is drawn, when the agitators or arms (being set out of square) drive the dried manure through the opening. The appearance now presented by the manure is that of lumpy dark-red loam, free from offensive smell or odour.

Having been allowed to cool, it is riddled, which reduces it to a friable, earth-like powder, a sample of which is now before you.

We have a ready sale for all the manure we can make, but as a means of helping off some of the ash manure (which we are still for want of power compelled to make) some is used to fortify it.

The price at which we sell is 6*l.* 10*s.* per ton.

Early after bringing the first machine into use our Corporation refused an offer of 3*l.* per ton for a term of years.

Although the scrapers or agitators do most important work, preventing as they do the forming of a film impenetrable to the steam, they do not prevent a cake forming on the side of the container, which has to be cut away with chisels once a week, and as this is quite a day's work, the machines must work in pairs unless night work be adopted, a course which small towns would naturally adopt.

The offal from slaughter-houses is also dried by the machines, the product being similar in appearance to that from fæcal matter.

The percentage of ammonia found in pail contents is 5 per cent., but the percentage found in the dried manure is from 7 to 9.

The commercial value of manure is estimated at about 18*s.* per unit of ammonia.

The chemical analysis of the manure is as follows, viz.:—

Insoluble silica	3·216
Lime	1·310
Oxide of iron and alumina	0·607
Sulphuric acid	1·885
Phosphoric acid	3·102
Sulphate of potash	5·586
Chloride of magnesium	1·910
Chloride of sodium	5·120
Sulphate of ammonia	22·191
	44·927
Organic matter	55·073
	100·000

It was my intention to simply lay before this Meeting the information I have already given, but from the importance of this question I wish to add that since the adoption of this process of manufacture will, from ignorance of the general public, almost always be opposed on the ground of anticipated nuisances, that the works need not be in the town, the excreta being easily removed in tank-waggons or boats, and that as to the nuisance where the works are in towns, as the pails before being removed are covered with a lid making them water-tight, and on their arrival at the works are emptied into the evaporator and treated with sulphuric acid, and the steam and fumes of evaporation, after condensation, are passed through a furnace, no nuisance injurious to health can arise; indeed, comparing our own works as a manufactory with other trades, many give out more offensive odours and few less injurious to health.

DISCUSSION.

Mr. **Vawser** (Warrington) said the paper opened a question of the comparative merits of water-closets and pails or earth closets, a subject of great interest to the profession, but one that could not be fully discussed then for want of time. The question to a large extent hinged on the supply of water, and the conditions of the sewer outfall works. In many towns the necessity of doing something, and so removing the nuisance attending the use of the old Lancashire midden had forced the pail system on the local authority. It was to be regretted that no better and more wholesome system had been invented. It added another to the great nuisances in our streets, and was not creditable to the age. An experience of some years in the working of the system satisfied him that no improvement had been realized by the introduction of the pail system, or if it had, it had been discounted by another class of nuisances which did not exist before.

Mr. **Longden** (Warrington) said he was a representative of a dry-closet system, following in Mr. Vawser's footsteps, but he had not been long enough acquainted with it to give an opinion. It must be remembered that there were many circumstances to be considered by Corporations and Local Boards which they knew better than the outside public. In Warrington, as far as he could could see, the sewage was composed of a great many elements. There were a number of chemical works there and other works where a great deal of acid was used, which found its way to sewers, and he was afraid that if they had a water-carriage system solely and went in for irrigation works, the matter which found its way to the sewers would be detrimental to any crops they might grow. By removing the excreta as they did and by the mode of manipulation they adopted, they did obtain a certain amount of manure, the proceeds of which reduced the taxation. He might state that in Warrington it cost for the removal of the excreta, the collection of the pail contents, and everything connected with the working of the depôt, 8*d.* per head of the population per annum. Perhaps by and by, when he had had a little more experience of the system, he might be able to bring the matter up with more information.

The President: Does the 8*d.* per head cover the working expenses and the interest on capital expended?

Mr. Longden: Yes, it covers everything; but it is in addition to the cost of drainage and sewerage.

Mr. Pritchard (Vice-President) said that, whilst thanking Mr. Hewson for the able paper he had read, he could not help but think that the pail system must be considered, in a sanitary sense, as a disgrace to the nineteenth century. He had seen the working of the system in one or two towns, and he could not conceive anything more offensive or obnoxious than this beastly way of disposal. He should like to ask Mr. Hewson, who some years ago had elaborated a very complete system of disposal of the sewage by means of filtration, whether the present system had been forced upon Rochdale, or whether it had been adopted from choice. Judging from what he saw of the scheme submitted by Mr. Hewson some years ago to a Committee of the House of Commons, he was inclined to think that it had been forced upon them.

Mr. Angell (Past President): The only remark I will make is to denounce as completely as possible, through you, Mr. President, the filthy, indecent, and disgusting pail system. I will not follow Mr. Hewson's remarks, but enter my protest against such a disgusting process obtaining in this nineteenth century.

Mr. Lemon (Past President) said they had on several occasions had instructions from the leading Members of the profession as to what should constitute a civil engineer. Now, he should like to know what should constitute a borough engineer. One thing was certain, that he must have a vast amount of moral courage. He was quite sure that those who advocated such a — he would not use quite such a strong expression as Mr. Angell had, but those who advocated such an abominable system as the pail system, must have a vast amount of courage. There might be something in the pail system if it got rid of the various difficulties attending the sewage question; but it did not solve them. Mr. Longden said they could not carry out a system of irrigation at Warrington because a quantity of acid found its way into the sewers. He should like to know whether the adoption of the pail system got rid of the acid. There were the same difficulties in a dry system as in a water-carriage system. Moreover, they knew by the blue books that the cost of drainage was about the same where the dry system was in operation as where the water-carriage system was. In Leeds and many other towns where they had a duplicate system, partly a water-carriage and partly a dry system, the cost of the sewers came out per head pretty nearly as much or about the same as in Liverpool or other towns where they went in thoroughly for water-closets. He meant to say this, that if any sanitary engineer were asked to design a system of sewers well knowing that the dry system was to be adopted, he could make no difference whatever in the size of his sewers. The difference would be so small that it would be entirely unworthy of consideration. He had gone into the subject very fully, and he had found that that was so; and therefore the same cost was required where there was a dry system as where there was a water-carriage system. This being so, why should they not avail themselves of that which everyone would admit was the cheapest mode of carriage, namely carriage by water, and dispose of excreta in that way instead of likewise resorting to a dry system? He was told that in some towns they could not get water enough, but he was afraid that was rather shirking the question. He was at a loss to see why in an ordinary town sufficient water could not be obtained, or that the water supplied for domestic purposes was not sufficient for the purpose of conveying away the excreta from the houses.

Mr. Procter (Bolton) said he happened to represent a town which to a certain extent had adopted the pail system, and probably he should not be doing his duty to himself or the town he represented if he were silent when hearing the statements of representatives of the water-closet system. If the pail system should be condemned, he thought it should be on other grounds than its "being a most disgusting system," "a disgrace to the nineteenth century." They should have arguments to support statements like those. They saw all that was disgusting about the pail system: they saw the collecting, unloading, and dealing with the fæces. With the water-closet system they did not see this. It was true that by the latter system they removed the excreta from their own houses, but they might trouble their neighbours perhaps miles and miles away. He did not say that a water-closet was not a convenience. He should be sorry to be without one in his own house but he did see great objection to the adoption of water-closets in cottage property amongst a manufacturing population such as that of his own town. Another very important question was the utilization of the stuff. They knew that when once they got it into a sewer they could not get it out again, and all the value in it must go. If they could irrigate with it, that was another question; but they all knew that the irrigation system was going to the winds very fast, certainly with regard to large towns. He knew of no town of over 100,000 inhabitants which had adopted the irrigation system with anything like success. Where the pail system was adopted they did utilize the solid matter and retain the agricultural value of the manure, which they did not with the water-closet system.

The HON. SECRETARY (Mr. C. Jones) said he was far from being a supporter of any of the abominations to which their friend Mr. Angell had so decidedly referred; at the same time he thought it behoved them calmly and quietly to discuss a question of this sort and see whether really the peculiarities and specialities appertaining to north and south might not develope different systems and different modes of dealing with and settling a great and national question. Therefore, although he went to Manchester and saw the pool on the other side of the abattoirs—certainly a scene of abomination if ever there was one—he thought there was a great deal to be said in favour of a pail system under some circumstances and in some places. He did not say that in the southern towns, but he did think that in many places there might be a means of dealing with this question, especially where the agricultural question was prominent, by which the solids could be utilized directly from the towns, and he thought it was a problem which was far from being solved. He was glad that Mr. Hewson had taken up the matter as he had done. There was no reason why because a thing was nasty it should be carried out in a nasty way. If he were fitting up a house of his own,—a detached house with a large garden, he would not have it connected with a sewer; he should just have earth-closets all over the place. Their late President some years ago fitted up earth-closets in his house in preference to water-closets, and his brother, and one of the inspectors of the Local Government Board, did the same. Therefore, it was not because they were strong advocates of the water-closet system that they should decry any other system in every possible way and with the strongest possible expressions. Experiments were being carried out at very great expense which might prove that there were other modes of dealing with the subject than their individual professional modes, and he hoped they might be so far successful as to prove that something might be done in connection with the solid manure.

Mr. Hewson, in replying, said he did not know that he had advanced any opinion as to whether or not he preferred a system of water-closets to the pail system. Of course, he knew, whether he was an engineer or not, that it was generally considered to be much more respectable to have a water-closet in one's establishment. If Rochdale had a tidal river and a good water supply, if even they had to go into the bowels of the earth for water, he thought that taking the sewage question and the water question together, they would do pretty much as Liverpool and Southampton were doing, and as Warrington was doing.

Mr. Vawser: Warrington has the pails.

Mr. Hewson: Yes; but it discharges its sewage into the river. It was all very well for gentlemen who were the representatives of towns where there were large tidal rivers to speak of the nastiness of the pail system, and all that sort of thing; but let them go into the North of England where town upon town was land-locked, and the operatives heaped and pent. If, to arrive at their cleanliness and clean appearance, they had to pay the price which would have to be paid in the North to get at the same result, he questioned whether they would have such pithy, barbed statements—such a conclusive, knock-him-on-the-head style of argument as some gentlemen had indulged in, he did not think they would. He considered the pail system better than the old ash-pit system. He came there to tell the gentlemen who were concerned in the utilization of the contents of ash-pits and pails, what they were doing in Rochdale. He believed they had made a discovery by means of which they would be able to utilize at a much cheaper rate than they had hitherto done. That was just about the sum of what he wished to say. It was very expensive formerly, but now and in future it would be much less so. He had purposely kept out of the way of giving opinions, not wishing to invite a discussion on the Water-closet *v.* the Pail System. Whether or not the pail system would be preferred to that of the water-closet time would show.

The President said it was quite clear that Mr. Hewson, as a representative of the pail system, was in a minority amongst them; but he thought it was extremely likely that if they had all had the difficulties to deal with that were met with in some of the northern towns, they would have been trying experiments at the present time of perhaps no greater promise than those which Mr. Hewson had detailed to them. He was one of those who thought that the greatest possible encouragement should be given to the making of experiments of every kind in connection with the sewage question. In Liverpool, they were happily relieved of any great difficulty by the existence of a noble river flowing past their doors at the rate of six miles an hour, and there was not the smallest nuisance in the river Mersey arising from the discharge of sewage into it. A remark had been made with reference to the difficulty arising from the greater consumption of water in towns in which water-closets were universal. That was a difficulty which existed only in the imaginations of those who had not thoroughly examined the question and had not taken the steps which he had taken in Liverpool to give a constant supply and high pressure without waste. Liverpool at the present time was supplying he believed of all towns in the kingdom the highest pressure, with a perfectly constant supply and the smallest flow of water per head of the population, notwithstanding the fact that nine-tenths of the people were using water-closets. They were only supplying on an average 15 gallons per head per day for hotels, public-houses, offices, shops, and all domestic purposes—15 gallons per head per day, including the water-closets; so that that was really a difficulty which was only imaginary, and he thought it was of the greatest interest to those towns which had adopted a system of irrigation to know that the total quantity of sewage might be reduced in most places by something like 50 per cent., and the sewage itself concentrated in the inverse proportion, because, of course, the real difficulty in connection with any system of irrigation arose from the great volume of diluted sewage which they had to deal with.

Thanks were voted to Mr. Hewson for his paper.

FURTHER REMARKS ON THE VENTILATION OF SEWERS.*

By E. B. ELLICE-CLARK, C.E.

One of the chief objects of the municipal engineer is to construct conduits for the conveyance of refuse from dwellings in such a manner as to increase the healthy condition of cities.

It is now an almost universally admitted sanitary canon, with those who have dismissed prejudice from their minds, that water is the agent which best removes filth from dwellings; though we still have those who, from want of education, prejudice, or some other cause, will not admit this, and continue to exercise their influence over municipal authorities in a contrary direction. The time, however, is approaching when this canon law will not only be admitted, but universally acted on. Too frequently sewers constructed for hygienic purposes have been so ill-designed and constructed that disease, instead of being stayed by their agency, has become epidemic. And however careful the engineer has been to see his work properly executed, it has been found a difficulty of no small magnitude to render the carriers of filth innoxious. Some may say the difficulty never has been overcome.

How sewers have been the means of spreading disease we are too painfully aware, and the contamination of air and water by modern systems has gone a great way to foster that opposition to water carriage which is so apparent in the sanitary authorities in the northern counties. It must be borne in mind that, exclusive of the injury to the atmosphere by the air of sewers, other gases and solids have been found existing in the air of cities equally prejudicial to health, and exist, in a greater or less degree, according to the density of the population, the character of the people, the nature of the buildings, the physical position of the site, the area of open spaces, and the impurities given off by factories. There are, however, towns where the conditions for obtaining the maximum amount of purity in the air are favourable, but where ill-constructed sewers, and an entire absence of ventilating them, have rendered these places as bad as the worst-built manufacturing towns.

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* See 'Proceedings,' vol. i.

The object of this paper is to show how the air is contaminated by sewer gas, what is the nature of the change taking place in the sewers, and, so far as the limited knowledge of the writer will permit, in what direction we should search for a means of preventing air pollution so as to be dangerous.

Four years ago this Association was addressed on the subject, in the hope that it would be followed up by those who have opportunities to place on record observations which would assist in passing something like a general law on the subject: for, however valuable the observations in one system of sewers may be, the conditions they work under are so essentially different that no amount of research and observation, however correctly recorded, or theories built up by a single individual, can be conclusive as to the best method to be adopted in all instances. Observations should be made in all localities and compared. This is all the more necessary inasmuch as opinions on the subject differ materially. Not many weeks ago a paper was read before one of the Engineering Societies of London, where the diffusion of sewer air into the exterior atmosphere was characterised as absurd, the author of the paper declaring his belief that air should be imprisoned in the sewers by so-called traps. Here was such a lamentable want of knowledge as to be barely credible. To prevent heated air, of a light specific gravity, ascending through a heavier atmosphere, is as much opposed to the laws of nature as to prevent heavy bodies falling through space by gravity. Yet we have those who deem themselves competent to teach their brother engineers, gravely lecturing before a scientific society on the absolute necessity of endeavouring to do that which is impossible!

Again, our late President informs us that the sewers of Bristol are not ventilated; and, furthermore, that having designed the system for that great city, had he to begin his work *de novo*, means of ventilation would not be provided. This most remarkable conclusion shows that engineers are by no means unanimous, not only on the means to be adopted by which to accomplish ventilation, but as to whether they should or should not be ventilated at all. Engineers and sanitary authorities are apt to form opinions on this subject from approximate and misleading data—the one standard with them being the death-rate, which has been arbitrarily fixed at something like 17 in 1000. It would be a bold statement, but very close to the facts, to say that the death-rate of any given town forms but a very rough index to the health of the inhabitants;

therefore, because the death-rate of Bristol is comparatively low, as compared with other cities, and the sewers are unventilated, it is not a *sequitur* that sewers do not require ventilation: yet this appears to be the reasoning of those who hold opinions contrary to the writer. No such general arguments, whether founded on facts or not, prove to demonstration the position taken by the other side. The author accepts the law laid down by those who have studied the subject. Sewers must be ventilated. Scientific medical men, who have devoted years of labour to the question, call on the engineer to accomplish the work.

The laws that govern the atmosphere, whether it is entirely free from compounds injurious to human life, or contaminated with animal and vegetable molecules, the products of acid fermentations, as in unventilated sewers, are those we must study previous to making observations on the means of ventilation.

The accepted composition of atmospheric air up to a very recent period was 209 oxygen, 791 nitrogen, with infinitesimal quantities of carbonic acid, vapour of water, and carburetted hydrogen; but the observations of modern chemists show that the analyses upon which these quantities are given are not to be relied upon when the inquiry extends to so delicate a matter as the effect on health; and it appears doubtful whether the analysis giving the quantities to four places of decimals per 1000 parts, enables us to determine the precise quantity of a given gas inhaled that would injuriously affect the human organs. The same may be said with equal correctness as to the nature of the gases, for it is only within a few years ozone has taken its place amongst the defined constituents of atmospheric air; and it would appear that there are still impure gases that elude the most searching and minute analyses. But if a standard of the greatest exactness has not yet been fixed, enough has been done to prove that when the loss of oxygen is in such a minute quantity as 190 parts in 1,000,000 below the normal quantity, it is a change that is considered important when considering health. No change, indeed, however small, is so unimportant as not to be noticed. To put it more forcibly, and to show how great results are produced by the smallest change, we see water lowered half a degree Fahr. become solid, raised half a degree become vapour; and we should make ourselves familiar with these apparently small changes. If 190 parts in 1,000,000 is regarded as a change of importance, how startling appears a change giving a diminution of 15,000 parts in 1,000,000, as has been shown to be the difference between the amount of oxygen in atmospheric air in a street and the air of the sewer below!

The air of every city is peculiar to itself—every house, every room of a house, has its own climate; every sewer, every section of a sewer, has its own climate; not only in the nature of the gases and the humidity of the air, but in the temperature and the currents—the contributing circumstances being such as to cause manifold changes being set up every hour and perhaps more frequently. It is not surprising to find almost a complete *carte blanche* in reply to queries put to engineers on the composition of sewer air. Only the most delicate instruments and searching analyses enable the chemist to determine when air contaminated with carbonic acid is injurious to health. To simply determine quantities of whole numbers per cent. is of no value—the inquiry must be much more minute. Carbonic acid is the principal gas inimical to health found in fairly constructed sewers. The smallest quantity in pure air is 332 parts in 1,000,000. Dr. Miller gives the mean of his analyses in a ventilated sewer at 1060 parts in 1,000,000, rising to 1320 parts when the ventilators had been filled with charcoal; but as much as 23,000 parts in 1,000,000 has been found in an unventilated sewer. The difference between this and 1060 parts is startling, and shows the extent of the contamination in broad relief; and the more so when we learn that the senses observe so small a difference as 34 parts above 369 in 1,000,000, that an excess of 700 is unpleasant, and that 1000 is injurious. In estimating the danger of air in sewers by the excess of carbonic acid, we must always bear in mind that it is difficult to obtain an atmosphere containing anything like this excess without organic matter existing, and it is probable in a sewer the two increase in a direct ratio. The amount of carbonic acid present in an ordinary house was found to be 540, in a bedroom at night 2300, in the pit of a theatre 2730, in a mill 3000 per 1,000,000—all of which places were unpleasant, if not unhealthy, and containing a greater excess than a ventilated sewer.

To have a pure and wholesome air we must have it with less than 700 in 1,000,000, and we can come to no other conclusion that if sewer air containing 23,000 parts finds its way into a house, accompanied by the smallest quantity of sulphuretted hydrogen, and other gases of putrefaction in whatever small quantities, the danger is so great as to be positively alarming.

The other noticeable difference between sewer and atmospheric air is the great diminution of oxygen, which has partly become carbonic acid and partly unknown, and probably still more deleterious, gases. In an unventilated sewer the oxygen has diminished from 209,900 per 1,000,000 parts to 179,300 (in a mine it has been as low as 182,700, but found to be unbearable). In a ventilated sewer 207,100—the average in the Metropolitan Railway was 207,000. This is a difference between pure air and an unventilated sewer of 30,000 parts in 1,000,000, and if the figures do not appeal sufficiently strong to our understandings we must inquire further what it does mean. The average quantity near a Lancashire midden was 207,000, in a cow-house the same, in a theatre with the temperature at 78° Fahr. 206,300—this is assured to be a change from bad to very bad air and dangerous to live in—in a law court the oxygen had fallen as low as 204,900, an atmosphere difficult to continue in long; indeed, when oxygen is deficient to the extent of 900 in 1,000,000 the air is impure; all gradations higher than this show the danger to human life, until the quantity is 170,000, when, in all probability, it would prove fatal; it has been ascertained that something like 174,500 was unbearable. Take this diminution of oxygen and the excess of carbonic acid, and we have sufficient to prove that, putting aside the organic substances floating in an unventilated sewer accompanying the gases, air is so changed as to be the source of great danger, and means must be provided to prevent such changes.

We now come to the organic matter floating about as solids, sometimes in such large quantities as to be plainly discernible to the naked eye. When Mr. Ashmead had an unventilated sewer in Bristol opened for the inspection of this Association, the writer placed his coat-sleeve over the opening and the solid particles adhered to the cloth; the upward stream of air was loaded with solids, so much so that it was perceptible to the eye, and took the form of a stream plainly defined against the clear sky, spreading as it increased in height, until it disappeared, dispersed by the currents of atmospheric air. Similar solids have been frequently noticed by the author when opening unventilated sewers. When a sewer in Derby was opened, he covered the aperture with fine, undressed linen, which formed a screen, and enabled the gases to pass through, but retained mechanically the solids; which in the course of half an hour were sufficiently numerous to give the cloth a blackened appearance. Unfortunately none of these were subject to a microscopic examination. What are these solid particles? Some organic, some not so; the latter are injurious to health negatively, or to a very limited extent only; therefore, in the presence of large bodies of organic matter, we need not discuss that branch of the subject. What causes putrefaction and fermentation, which produce organic substances, is only a matter of conjecture; the outer atmosphere produces these causes, and when deposited on what have been aptly termed "feeding places," animalcules are quickly developed. The human breath condensed and burnt will give the material for organic matter, and the engineer must accept the theory that from the exterior atmosphere germs find their way into sewers, where the conditions of multiplying them, if the sewers are unventilated, exist to an alarming extent. Disease follows, for there are no known means of preventing sewer air containing the gases of putrefaction ultimately passing into houses that are directly connected therewith. The author has recently ventilated a sewer, which for thirty years has been closed as completely as such places can be. There was no deposit in the sewer, but it discharged into a sewer having a deposit of 6 inches in depth for some length, always covered with sewage. The sides of the former sewer were covered with fungoid growth to the thickness of half an inch, at first sight having all the appearance of "muck" such as would come from a dirty river bed; on closer examination it was found to contain bacteria, and much larger forms of life, indeed it was largely composed of living organisms, many visible to the naked eye, some being in appearance similar to chrysalides, and well-developed cells. The mean temperature of this sewer from many observations was found to be 59°·1 Fahr., while the hygrometer showed complete saturation of the air. This deposit in a humid atmosphere of a high temperature gave off a most disgusting odour, and burnished silver almost immediately became discoloured, while the white paint of the thermometer cases in the course of three days was entirely discoloured, as if it had been dipped in a solution of nitrate of silver; attempts were made to ascertain if the gas was inflammable, but without a satisfactory result, i. e. it could not be lighted. In this case the heated moisture of the air had favoured decomposition and the escape of odour was increased in consequence; the organic matter, covering ·42 of an inch in thickness, was the accumulation of years; it would appear as if the solids in the air had been attracted to the sides and then were caught or deposited;

here we have a type of many miles of unventilated sewers, containing the germs of disease, with their vitality dormant while the temperature was kept low, but ready to spring into awfully active life when the temperature was raised.

The summary, then, of the foregoing is, that in a system of sewers, as in Bristol, without ventilation we have the air deprived of a great quantity of oxygen and ozone (the latter completely obliterated), with an excess of carbonic acid and sulphuretted hydrogen, gases that are prejudicial to health. We have living organisms produced and growing in extent and number every hour the sewer is above 55° Fahr., organisms that are not created to die at once, but in a humid warm air live for years, all produced by want of oxygen and ozone, or, in other words, by want of ventilation.

The author will not discuss the various methods that have been proposed to effect the ventilation of sewers. They have ranged from having cast-iron cylinders over the sewers with furnaces therein, feeding exclusively on the gases, the flames from which were to act for street illumination in lieu of gas, to the manufacture of oxygen within the sewers themselves; many of them highly ingenious, but showing an entire absence of chemical knowledge. None of them have held ground after the experimental stage, except the attempts to neutralize the air by placing charcoal between the sewer and the point of exit at the ventilator. These were examined in a former paper, but this so-called system of ventilation has been almost entirely abandoned. We have seen the temperature rise from a mean of 50°·5 Fahr. to 59° Fahr., while the $C\,O_2$ has risen from 1060 to 1320 parts in 1,000,000; while the mean velocity of the air was reduced from 332 feet per minute to so small a current as to be inappreciable to the anemometer during a period of sixteen days, when the charcoal was removed; the mean velocity for the next sixteen days, when the experiments were concluded, was 324 feet per minute. By raising the temperature, a movement of air was created, but the charcoal interrupted the air waves, at first only partially, afterwards, when the charcoal became saturated with moisture and covered with dust from the road, wholly so; the rise in temperature above 55° is of great importance, as there is a marked difference in the rapidity with which bodies putrefy above this, and it is questionable if sewers could be kept at a temperature below that, whether the gases of putrefaction would ever be formed.

Putrefaction appears to go on in a direct ratio to the increase of temperature from 55° to a little more than 130° Fahr. Hence the introduction of charcoal, or, in other words, the cessation of ventilation, has the effect of decomposing the air, and the matters then become entirely changed and take an organic form. When atmospheric air is again permitted to enter, the decrease of gases and solid organic matters is in a direct ratio to the amount of oxidizing matter introduced, and finally the whole is removed.

To clean a sewer of gases and fungoid growth as previously spoken of, the author has constructed a screen which is placed over an opening in the sewer when the wind is blowing, fresh air is thus mechanically taken into the sewer.

Ventilators 60 feet apart have been formed, and oxidation is rapidly reducing the growths spoken of. Some of the bricks with the growths intimated have been removed and kept for six weeks in the open air; the growth has now almost entirely gone: it has been reduced in thickness from ·42 of an inch to ·09. The temperature of this sewer has been reduced from a mean of 59°·1 to 52° Fahr.

Thus charcoal, by impeding the entrance of atmospheric air into the sewers, practically seals them and brings about all the conditions found in sewers entirely without ventilation. So that after nearly forty years' discussion we come back to open ventilation as the best known practicable means of rendering sewer air innoxious, or of assimilating it to the air of the surrounding atmosphere. The reasons may be briefly stated. Closed sewers bring the air to a point of complete saturation, and this moisture at a high temperature favours putrefaction to a remarkable degree; but when the temperature is low, the moisture is an agent of purification, as the organic matter is to a great extent washed out, and the mere lowering of the temperature destroys, with the moisture ever present, a great source of evil; possibly the only source of danger.

We have seen that organized germs, if they exist, are inactive while the temperature is low, and if putrefaction is prevented the organic matter is not created in the sewer; that which enters from the fæcal emanations of typhoid and other patients are placed under conditions fatal to their development.

The results of the observation of the author for moisture show that in unventilated sewers the air is saturated to its fullest capacity, which rises with the temperature. At 50° Fahr. a cubic foot of air will absorb 4 grains of water, the air being in a normal condition of humidity, i. e. containing 75 per cent. of moisture; when the temperature is raised to 70° Fahr. 4 grains more of water are absorbed. The observations with the wet-bulb thermometer showed complete saturation in all the unventilated sewers, and a mean of 2° Fahr. (with the thermometer reduced to 50° Fahr.) less in a well-ventilated sewer; though in those pipe sewers ventilated with shafts 12 inches in diameter, placed at a distance of 200 feet apart, the air was completely saturated; the mean temperature of these sewers being 5° Fahr. less than those not ventilated, and 2° Fahr. higher than the well-ventilated sewer. This lowering of the amount of moisture in the air is of great importance, because, from a law of nature, which is not yet clearly understood, vapour of water is a vehicle for organic matter, favours decomposition, and facilitates the escape of odour—bodies that are moist give out more organic vapours, probably from the increased rapidity of their formation. The odour in all the unventilated sewers examined by the author has been much more clearly perceptible than in those ventilated. In the sewer described as well ventilated, no odour has been perceived since its construction, seven months ago; while the sewers having smaller areas open have, during certain times, had most perceptible stinks in them.

The odours from all drains are popularly supposed to be greater before rain, and the author directed his observations in the sewers to ascertain the truth of this; they have not been so complete as he could have wished, but sufficient to indicate that with a fall in the barometer and a rising dew-point, the air in the sewers was raised in temperature and humidity, and the escape of the gases at the ventilators most plainly perceptible. These observations are very simple, and would be of much value as indicating the time when sewers should be flushed, which accomplishes the object of lowering the temperature, absorbing the gases, and mechanically removing the matter quickened into active putrefaction by the action of the external atmosphere.

All the attempts to make upcast and downcast air-shafts constant have failed. Out of 100 ventilators observed by the author, not one had been constant in its action—except that to a limited degree the shafts are both upcast and downcast at the same time—for when the gases from the sewers, either acting independently or homogeneously, are in the act of escaping, they contract, and atmospheric air flows into the aperture mechanically to fill up the deficiency caused by their escape; and in this way from apertures in the sewers as much atmospheric air finds its way in as sewer air out, and is one of the chief points of success attending open ventilators at the street level.

The disposal of sewer air by carrying pipes up the sides of houses is a mistake, as it impedes the free action of the currents, unless they are of such large diameters as practically cannot be obtained; the angles as well as the sides of pipes impede by friction the ascending power of the gases, which is by no means great; sewer ventilation by rain-water or other pipes of small diameter cannot be accomplished. To pass sewer air up such columns there must be either pressure from below or an induced current, and the action of ventilators constructed for the latter purpose has recently been proved abortive. With a view to ascertaining whether in an unventilated sewer there was sufficient pressure—if that term can be applied to a movement of gases, the specific gravity of which only differs from atmospheric air by a few places of decimals—to force the air up a pipe, observations were made with a pipe 6 inches diameter, 30 feet high, with three right angles. At the opening in the sewer the movement of the air was so slight as not to be appreciable to the anemometer, but the flame of a candle was for 35 seconds attracted towards the opening, and then ceased in movement altogether; the anemometer at the top of the pipe remained stationary, although there was a faint odour escaping; and as the amount of atmospheric air would be proportional to the escape of gas, nothing like the quantity of atmospheric air required to oxidize the gases and to lower the temperature of the sewer could be so admitted. If it were possible to seal sewers so that none of the gases could escape, ventilation would not be required; but the gases being there, and a direct communication existing between the sewer and each house, means have been provided to prevent the discharge of the sewer air into houses by water, intercepted in what is familiarly known as a trap; that water, as coming from the clouds and bringing a large amount of oxygen with it, or water from the ordinary town supplies, will for a time resist the action of such gases as are found in unventilated sewers, is beyond dispute; but there is a limit to such a capacity. Pure water contains 65·1 nitrogen and 34·9 oxygen; but the greater portion of the oxygen is removed when the water is attacked by gases, and oxygen is also removed when the water contains organic matter, carbonic acid taking its place. River water containing organic matter has given CO_2 30·3; nitrogen 15·0; oxygen 7·4.

63 cubic centimetres of river water—	CO_2	48·3
" " "	Nitrogen	14·5
" " "	Oxygen	0·25

This shows the extent to which water will absorb gases, especially carbonic acid. A litre of water shaken freely with large volumes of air will, at 60°, absorb 17·95 centimetres of air—viz. 65·1 nitrogen, 34·9 oxygen per 100 volumes. So soon as the water in a trap becomes charged with sewer gases, they are given off or escape by levitation, according to the respective specific gravities of the gases attacking the water, and so the value of water as a preventive to sewer gases entering a dwelling depends entirely on the attacking force of the gases in the sewer; without any ventilation, the ordinary trap would not resist the gases more than three hours if the water remained unchanged, as it does during the night; so that in all those towns having unventilated sewers, the gases pass into the houses having communication therewith. When the CO_2 has been reduced by oxidation, i. e. by the retention in the sewers of the mean amount of oxygen in the air, water traps prevent sewer air entering houses; though if sewers were entirely open, traps would be worse than useless, as every trap more or less retards the velocity of the new sewage; thereby contributing an element to its decomposition.

The best method of ventilating sewers, if practicable, is to have them open; if all sewers could be open impervious conduits, no such gases, as are now found, would exist, the air in the sewers being brought to a similar condition to that of the surrounding atmosphere, as has been shown, and the requisite changes to produce organic matter would be absent. If engineers see their way to have open sewers practicable, the question ends, and when designing them the nearer they attain this the nearer have they solved the problem. What is the minimum amount of atmospheric air required to ventilate any given sewer cannot be ascertained by a formula, but an approximate indication may be drawn from observations made in a sewer 300 yards in length (3 feet 9 inches by 2 feet 3 inches), where the ventilators were 225 feet apart, having an open area of 20 feet, this amount of ventilation proving unsuccessful either in permanently lowering the temperature or reducing the humidity of the air. The ventilators having been increased to ten in number, with an area of 46 feet, reduced the temperature to a mean of 51°·5, and the dew-point 1° less than formerly.

The author is conscious of the many points that are not touched on in this paper, such as the cowl heads always turned to the wind, which have been found to answer well in narrow streets, and the induced currents by funnels, and many other systems which he hopes will be raised in discussion, the subject being a most complicated one, and the paper he has written by no means so exhaustive as he would have made it had he had more time to spare than that which has been snatched from professional labours.*

DISCUSSION.

The PRESIDENT said he believed he had read pretty nearly all that had been written on the subject of sewer ventilation, but he confessed that he had never read or heard of so complete a set of carefully-made experiments as Mr. Ellice-Clark had laid before the Meeting. Mr. Clark had taken up, so far as he knew, an entirely new line, and had done precisely the work which he (the President) had long desired to do, but which he had never found time to complete. To his experiments on the velocity and motion of gases and air in sewers, he had added the consideration of the chemical conditions and the conditions of life which existed in sewers, and unless they combined the three considerations they would do very little good in investigating the subject.

Mr. ASHMEAD (Past-President) said that as his name had been freely mentioned in the paper, he presumed it was expected that he should make some sort of reply. He must say that he thought Mr. Clark had proved too much. He had proved that no method of ventilation had succeeded; and the only thing that he considered should be done now was to have open sewers, consequently no ventilation would be required. He said that the gas would pass through the water into the houses, but he had not considered that there were other traps than water-traps, namely, air-traps, and that if the two were combined they might prevent the gases passing the traps; also, that if they had the house drains ventilated, instead of the sewers, they would not get the gases into the houses. It was unfortunate, he thought, that Mr. Clark had not examined those solids that he detected in the Bristol sewers. He (Mr. Ashmead) did not know that they were in existence. He did not see them himself, and he did not know whether any other than Mr. Clark saw them, but it would have been more satisfactory if the Association had been informed of what those solids consisted. He (Mr. Ashmead) was not there to advocate the the non-ventilation of sewers, he was merely there to express his own opinion, and he thought the Engineer of any town should adopt his own opinion for his own town, and say what he thought was best. Mr. Lemon once said he thought the Bristol sewers must be a myth altogether, that there was nothing to be seen in the streets anywhere, that there were no open ventilators, and he thought they must be on paper only; but he was able to show the Association, when they visited Bristol, that the sewers were not entirely out of sight nor myths, that a great deal of money had been spent in making them, and that they had been in working ten, twenty, and some thirty years, without any complaint of want of ventilation. The medical officer was so satisfied that they did not require ventilation, that he believed that in less than ten years they would all come to the same opinion. Mr. Rawlinson, having seen an account of the Meeting at Bristol, wrote to him (Mr. Ashmead) to ask if it was correct. He replied that it was, and Mr. Rawlinson then sent Major Tulloch down privately to inquire into the facts. He was taken over the works: the sewers were opened for his inspection, and he expressed himself perfectly satisfied that ventilation was not required. Under these circumstances he thought he should be very wrong if he recommended his board to spend 10,000*l.* or 12,000*l.* in putting ventilators in the streets when he did not consider that they were required.

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* Authorities consulted: Smith's 'Air and Rain,' Sir Joseph Bazalgette's Reports, Dr. Miller's 'Analyses of Sewer Air,' Dr. Carpenter's 'Preventive Medicine,' Reports of G. F. Deacon, C.E., and J. J. Nicholson, F.C.S., Professor Graham's 'Laws of Gases,' 'Transactions' of the Royal Societies of London and Edinburgh, and the Association of Municipal and Sanitary Engineers and Surveyors.

Mr. LEMON (Past-President) said he did not think Mr. Clark intended to say, or intended to show, as had been stated by Mr. Ashmead, that no method of ventilation had succeeded; he merely showed that if they could get open sewers it would be the very best thing to do, as an illustration of the reason why they should get as much ventilation as possible. In other words, they should not only provide ample means of letting out the impure air, but should provide also ample means of letting pure air in, so as to provide for the proper diffusion of the gases. He (Mr. Lemon) had probably had as much experience as any Member of the Association in sewers themselves. He had made a subterranean survey, and measured up a large amount of the Metropolitan Sewer System, and he might say that he never enjoyed better health in his life. That was due to the very excellent way in which the sewers were ventilated—to the very large area of those sewers allowing of the free inlet of air, and likewise to the large volume of air in proportion to the amount of sewage matter flowing through them. He was thoroughly convinced that they must ventilate their sewers, and ventilate them as much as possible, and he thought that attempts on the part of Engineers to what he called "bottle-up" stinks was a mere farce. They could not do it, it was impossible. They could not prevent the escape of gases. What were called "sewer traps" were mere delusions and snares, they were nothing of the kind. In nine cases out of ten they were syphons, not traps at all, and the very best thing they could do was to make every system of sewers and of house drains as open and free as possible. He went in thoroughly for the system advocated by Mr. Norman Shore. He had the sewer pipe in his own house ventilated in the ordinary way by carrying it right up; he was now going to adopt what he considered the proper course—open it at the bottom so as to get a free current of air running right through it, and he had no doubt that the experiment he was about to try would be as successful as those which had been made by Mr. Norman Shore. But he thought he could support Mr. Ashmead in one particular, and that was, that there was not that necessity for the ventilation of sewers if the sewers were properly designed for their work. With regard to the Bristol sewers—although he said on one occasion that he did not believe they existed, of course that was a mere argument which he might, perhaps, be allowed to use in the course of debate—he might say this of them, that they were a very excellent and well-devised scheme, properly proportioned to the work they had to do, and they had all got excellent falls. The result was that there was very little deposit at all. (Mr. Ashmead: None.) Well, that being so, of course there was not the opportunity for gases to generate, because, after all, they only got gases from the decomposition of the fæcal matter; and if the sewers were properly designed, if they had proper falls and a proper supply of water, then there was very little need for ventilation. (Mr. Clark: No, no.) Perhaps Mr. Clark would hear him out before he said "No, no." Still, if they had what he might call, if possible, perfection in design in a system of sewers, he should still provide ventilation, because they knew that there was nothing perfect in man, or that which he designed. Then, again, as regarded the death-rate in towns, he thought that was in a great measure rather delusive. It did not follow because they had a low death-rate that the town was a healthy town. They must rather take what Mr. Clark had called the "disease rate." In his own town, Southampton, in one district there was a very low death-rate, but he knew from the returns furnished to the medical officer that there was a very great amount of disease there, although very few deaths occurred. Therefore, the death-rate was not so very clear an indication of the healthiness of a town, as some people might think. As regarded the ventilation of house drains to which Mr. Ashmead had referred, of course they all went in for that, but that was only secondary to the ventilation of the sewers. They ought to ventilate their sewers, and they ought to ventilate their house drains. As regarded the remark made by Mr. Clark in his paper as to ventilators forming up- and down-cast shafts in themselves, he (Mr. Lemon) was going to try the experiment, which was familiar to every student, of dividing the ventilating shaft down the centre, so as to make it an up and down cast in itself, not only letting out the impure air, but letting in the pure air in the most efficient manner. He thought the Association was very much indebted to Mr. Clark for his excellent paper.

Mr. PRITCHARD (Vice-President) said he considered that not only were the thanks of the Sanitary Association due to Mr. Clark for his excellent and comprehensive paper, but that all sanitarians must feel a certain amount of pleasure in reading such an able paper. He might say that he agreed entirely with the remarks of Mr. Ellice-Clark in connection with open ventilation. Although the Bristol sewers were evidently very excellent sewers, he could not help thinking that many of the house drains were connected directly with the atmosphere. It had been said by Mr. Lemon that the house drainage was a secondary consideration; but he (Mr. Pritchard) considered it a primary one, because sewer gases would naturally rise to the highest point, and assuming that there was not a ventilator in the sewers at all they would be completely ventilated if every branch drain were connected with the atmosphere. In his practice he had all along found that not only to connect the house drain with the atmosphere but also to ventilate the sewer at different convenient points, not a great distance apart, had been the most successful way of dealing with the subject, and in no case with sewers and drains so constructed and ventilated had he experienced any difficulty whatever from noxious gases. He thought Mr. Clark had done very good service indeed in submitting the paper he had read, and he hoped that in a short time the feeling in favour of open ventilation would be general.

Mr. EDWARDS (Burnley) said there was one point in Mr. Clark's paper with which he entirely agreed, and that was that they should not ventilate by rain pipes, which were merely conductors of sewer air into dwellings. Those ingenious people, speculative builders, did not generally put very good joints in their pipes.

Mr. COLE (Hereford), having had sewers under his supervision for the last twenty years, had found from experience that ventilation very much improved the state of the air in them, and his opinion was that they could not ventilate sewers too much.

The HON. SECRETARY (Mr. C. Jones) said the paper generated inquiry, and led them to investigate the matter more fully than they could do then; therefore, so far it was exceedingly valuable. It led one to see the importance, with such differences of opinion existing, of being exceedingly careful and watchful in reference to the various lines of sewers they laid down. The bearing and ventilation of each one must depend on its gradient and the peculiar position it occupied. The Bristol sewers had been thirty years in existence and they had proved a great success; but there were specialities attaching to them which did not attach to others. In every line of sewer they must take the gradients, subsoil, water, and so on, and let every question of ventilation bear upon the state of things existing. He agreed with Mr. Lemon that the ventilation of main sewers required less consideration than the ventilation of house drains. He should care very little as to the condition of the ventilation of the main sewers, if he knew that the house drains were thoroughly ventilated, and he could not help thinking that this was a point to which their attention should be directed. He should have liked, if time had allowed, to refer to the "Model Bye-Laws," and particularly to direct attention to the points laid down with respect to the ventilation of the house sewers and the absolute disconnecting of the direct line of current between the main sewer and the house. The up-cast shaft or ventilating shaft—rain-water pipe or whatever it might be—had been to a great extent a snare and a delusion. It had been found that an inch, or an inch and a quarter pipe was perfectly valueless, and he thought the greatest importance of these Model Bye-Laws was that they had drawn particular attention to the importance of making the ventilating shaft a direct continuation of the soil pipe, the soil pipe being a 4-inch pipe, certainly the ventilating shaft out of it ought to be not less than 3 feet 6 inches. He thought they could almost dismiss this vexed question of the ventilation of sewers and be perfectly assured that no gases whatever would find their way into their homes if these ventilating down shafts and up shafts were of sufficient area.

Mr. Ashmead (Past President) said it was really his opinion that this was the thing to be done—to cut off the house drains from the main sewers, and to ventilate the house drain. What then did they want to ventilate the sewers for, if they did not want to go into them for cleansing purposes? He did not want to go into his. His manholes were all closed down, and they had not been looked at since they had been constructed.

Mr. Lemon: In fact, you don't know whether they are there at all.

The President said there was one point in the paper which he thought led to an inference which Mr. Clark did not intend. He said: "The disposal of sewer air by carrying pipes up the sides of houses is a mistake, as it impedes the free action of the current, unless they are of such large diameters as practically cannot be obtained; the angles as well as the sides of pipes impede by friction the ascending power of the gases, which is by no means great; sewer-ventilation by rain-water or other pipes of small diameter cannot be accomplished." In that statement as it stood he entirely agreed with Mr. Clark; but he believed that when sewers were thoroughly well ventilated, and when there was a proper proportion of oxygen in the air of the sewers, they were in so perfectly satisfactory a condition that there was not the smallest objection to connecting the rain-water spouts with them. If the rain-water spouts were connected with the sewers, although he quite agreed with Mr. Clark that they were utterly useless by themselves, he quite believed from his own experiments that they assisted the ventilation. But let it be perfectly understood that he would not connect them for one moment until he was perfectly satisfied that the sewer had a current of pure air through it. With this explanation he thought that Mr. Clark's system and the Liverpool system were identical. If they would allow him, he would say one or two words, although it was rather a digression, on the subject of the ventilation of house drains. Not very long ago they were told that cowls were of no use, and he did not in the least wonder at the conclusion come to by a body of men in respect of cowls. At the time different people were invited to send in samples he was so busy that he could not send in what he had found best in Liverpool; at least, as a matter of fact, it was overlooked. He had made a very large number of experiments on cowls in use in Liverpool at the time he was appointed seven years ago. There were something like a thousand up-cast shafts on the branch sewers of courts, and it was believed that those shafts were doing a great deal of good. In a report which many of them had perhaps seen, however, he showed that they were really only doing good within a very few feet, or yards at most, of the points at which they were connected with the drains; and he found also in the course of his investigations that the draught was just as good, or very nearly as good whether the cowl was on the top of the pipe or not, except in cases in which there was a good wind blowing, and the cowl was going round at a pretty good rate. This led him to investigate the theory of cowls.

The President here explained the operation of cowls by means of a rough sketch, and exhibited one of his own construction, which he remarked was not patented.

Mr. Lemon: Do you happen to know what kind of cowls they were which were investigated by the Sanitary Institute?

The President: I do not. I am sorry I did not send one of these.

Mr. Lemon: According to the two experts who examined them, they were perfectly useless.

A Member asked the President if his attention had been called to a cowl made, he believed, at Stroud, and called Milbourn's Cowl. The President's illustration reminded him of it, as far as he could see the two were quite identical.

The President: Has it not got a screw inside it?

The Member: No screw at all.

The President: I have not seen it, but I don't profess that this is original at all.

Mr. Ellice-Clark, in replying, said he had only one gentleman to reply to, and that was Mr. Ashmead, of Bristol. And, first of all, he should like to dispose of the general statement Mr. Ashmead made with regard to a certain inspector of the Local Government Board going down to Bristol and, in the course of two or three hours or days, having had two or three, or perhaps 200 or 300 of the principal sewers opened to him, giving an opinion as to whether the sewers required ventilation or not. No man in the world, however great his attainments were, could decide such a delicate question, such a difficult question as the ventilation of sewers, by a cursory examination of that character. He should be very sorry indeed to say a single word which would reflect upon any gentleman of so high a position as the gentleman named, but he must say that he did not value the opinion he gave on that occasion one iota: it was utterly valueless. Then, with regard to the non-ventilation of the sewers of Bristol, he should have been pleased, and much more satisfied, if Mr. Ashmead, and the certainly most able Medical Officer of Health for that city—for he thought he was one of the most distinguished men in the world in public hygiene—if they had made observations in the sewers themselves. To simply say that the sewers required no ventilation because there had been no complaints, proved nothing. There were plenty of towns in England now where the sewers were perfectly unventilated and the people did not complain, but that proved nothing whatever. It did not prove that the sewers did not want ventilating because probably for the time being there were no epidemics of cholera or typhoid. He did not say that if they could insure a perfectly healthy population, ventilation of sewers would be absolute needful, but they must look at all the surrounding circumstances. There came an epidemic, irrespective of the sewers—an epidemic of typhoid or an epidemic of cholera. The discharges of the patients, however careful medical men were, were sure to find their way eventually into the sewers. Medical men, as they knew, always advocated that these discharges should be either burned or buried, but they could not insure that; and when they had, as they had in London, Liverpool, and other large places, epidemics of typhoid, there went into the sewers the germs of disease. Of course this was a complicated subject, but he thought Engineers must accept that theory. Mr. Ashmead said the sewers had such gradients that everything was completely washed out; but he could not agree with him that, whatever gradient a sewer had, they could wash that sewer perfectly clean. All sewers had a maximum and a minimum flow. In most towns the sewage was at its maximum height between eleven and two.

When the sewage subsided, the floating particles, to a very great extent, adhered to the sides of the sewer, more or less, according to the smoothness of the sewer itself. In brick sewers they adhered to a very large extent; but they could see in a homely illustration how even smooth pipe sewers might have these particles adhering to them. If they went into a dairy they would see cream adhering to the smoothest possible surface; and precisely the same thing took place in a sewer. When the whole of the perimeter was wetted and the sewage subsided, small particles of excreta were left adhering to the sides, and the sewer not being ventilated the temperature was raised to an enormously high extent. Then, given a sewer with a portion of the perimeter covered, or partially covered, with these particles from typhoid patients, and with the temperature raised to something like 60 degrees, a most deadly gas was generated, a gas of a very light specific gravity, a gas which completely overcame the thirty-five parts of oxygen in the water. The ingenious means which had been devised of late for the separation of house drains from the sewers, had to bear the test of observation and experience. He believed the best plan of ventilating house drains was, as Mr. Lemon had said, to have the down pipe as large as possible, and to disconnect them by having it open. A water trap did not intercept the gases at all after a certain period, the water becoming completely impregnated with the gases. During the day, probably, there was no trap that was not changed every few minutes, but during the night the water became completely discoloured and the gases passed through in bubbles, so that water-traps were of no value whatever, except during the day. He could not see what possible objection any man could have to having open ventilators. He believed that, so far from the sanitary engineers of this country coming to the conclusion that they were all going to bottle up the stinks, Mr. Ashmead's sewers would be ventilated in ten years time. He did not know whether Bristol had been visited by an epidemic of typhoid or cholera since the sewers had been in operation. That was the test. If the Bristol sewers, after a wave of that kind had passed over the town, proved to have assisted the Medical Officer in staying cholera, certainly he should be very much surprised, and it was possible that under the circumstances they might come to the same opinion as Mr. Ashmead; but until the Bristol sewers had been through a trying ordeal of that kind, he did not think they would adopt his system of non-ventilation.

The question upon which he touched in his paper about death-rate and disease-rate perhaps more affected the Medical Officers of Health, but they might go home and talk to their Medical Officers; and he certainly thought that a disease-rate ought to be compiled, because in certain localities there was a low state of vitality apparent to medical men where the death-rate was not high. He did not think the death-rate was of any great value. Mr. Jones's opinions somewhat bolstered up Mr. Ashmead's, but they were somewhat general, and general statements could not be accepted. They must have long-continued and minute observations; they must accept nothing on broad principles.

The Hon. Secretary said there was not time to particularise on many of the points touched on in the paper, and because one had touched on half-a-dozen points and not elaborated them, it must not therefore be taken that they were points on which he had not formed an opinion. There were many points in the paper, however, which they might take home and think over.

The President said he thought Mr. Clark said that it was desirable to have the whole of the soil pipes open. He entirely agreed with Mr. Clark in that, and he thought that wherever that could be done it should be done; but to have the soil pipes open would not necessarily keep the whole of the pipes up to the pan of the water-closet in a perfectly satisfactory condition, for they knew the soil pipes alone were in a very objectionable condition sometimes, and must, he thought, inevitably be so, and it seems to him that by adopting a very short length of lock, as it were, they had the smallest possible length of soil pipe to ventilate for the particular purpose of the dwelling which it entered. He was sure they must all be very much obliged to Mr. Clark. He only wished they had had a little longer time to discuss his able paper. He should read it in detail with the greatest possible interest and advantage.

Thanks were voted to Mr. Clark for his paper.

The President said there were one or two things he wanted to show the members of the Association that afternoon which he should have some little difficulty in explaining to them, as some of them would be seen in the street. The first was an entirely new kind of valve which he believed had been before no body of engineers yet. They would then go to the junction of two streets and they would see there above the pavement a gauge giving the pressure in the water main. There would be another gauge alongside of it, also giving the pressure; the two pressures being different, one being the inlet pressure to the valve and the other being the outlet pressure from the valve. The outlet pressure would be about 28 lbs. and the inlet pressure about 70 lbs. The outlet pressure was the pressure to which the district supplied by the main was subjected, and the inlet pressure was the pressure available for fire purposes. By the reduction of the outlet pressure a great saving of water was effected, and there was also a great saving in the repairs of leaks and a great diminution in the wear and tear of fittings. In a few cases the reduction of pressure had been from 110 lbs. to the square inch to about 25 lbs. Of course when a fire took place in a district they wanted the full pressure; and the valve was so constructed that immediately a fire took place it opened fully and gave the full pressure available in the district under any circumstances. They would see the two pressures indicated. They would then see a hose a little way down the street discharging a jet of water. That jet of water would be the diminished pressure due to the reducing valve, because he had given orders for that particular reducing valve to be put in gear so far as the reducing valve was concerned, but put out of gear so far as the automatic arrangement for going off at full pressure in case of fire was concerned. They would thus see the effect of the ordinary reducing valve. By turning on a little tap the automatic arrangement would be put in gear; and then, on putting a hydrant in work for a fire, they would see the water all at once spurt out at full pressure, automatically, simply by the action of opening the hydrant. The President explained the construction of the valve by means of a diagram.

Mr. LEMON said there was one matter not quite clear to him. Supposing a fire had just taken place and the fireman had just put on his hose, then the valve was opened by the abnormal consumption.

The PRESIDENT: Opened to the full extent.

Mr. LEMON: What was the difference between that state of things and a large amount of leakage going on from the main?

The PRESIDENT said these gauges were put on in the waste water district. There was a flow of 2,000 or 3,000 gallons—he did not care what it was—whatever they found was the maximum that a district took, leakage and everything combined. The valve was set by means of a screw so that it would never go off except when the ordinary leakage and supply to the district was supplemented by the opening of a hydrant which, as they knew, gave two or three times as much as the ordinary flow into the district.

Mr. Lemon: You mean to say you must have a greater force to pull the trigger than you ever get by waste?

The President: Certainly. The only difficulty that was met by this automatic arrangement was in cases in which sewer flushing was carried on direct from the water mains. There, hydrants were opened exactly in the same way, and the valve went off to the full pressure. The only result was they got more water to flush the sewer. The men went away, leaving the valve alone, and in three hours it had gone right again—gone back to the normal state of affairs. After seeing this valve in operation, they would go to the Lime Street railway station and see the new roof, and Mr. Thornhill the Resident Engineer would show them over the works. They would then go to the Hotham Street depôt, where he would show them all the apparatus—waste-water meters, valves, the apparatus for testing and stamping fittings, and a steam gauge which he had just constructed for the purpose of sending down to a district in North Wales, where he was gauging, and which, being very much out of the world, he did not want to visit too often. It was constructed to go for three months without stopping and it drew a line in ink, which, he might say, could only be produced by means of a pen which had not been used except for Mr. Froud's well-known experiments on ships' lines and ships in general for the Admiralty. Mr. Froud had succeeded in producing a pen which was almost everlasting, capable of being used with all automatic machinery of this kind. They would see what a perfect line it made. Then they would pass two road rollers of different kinds which he had ordered to cross their path. Then they would go to a flushing tank in Brownlow Street and see a sewer flusher. At this flushing tank there would be a locomotive flushing apparatus, which was the suggestion of Mr. Huntington, a Member of the Liverpool Town Council, and for certain purposes had worked out well. It contained about 1200 gallons of water and could be wheeled about from one place to another; and it saved the cost of flushing chambers. Then they would go on to Brownlow Hill Yard where they could see cement testing, manhole covers, &c. They would also see the Ashton Street asphalt pavement; and on their way they would cross the Grove Street pavement, which some members spoke of as being very good. It was artificial asphalt.

Mr. Angell (Past President): Mr. President and Gentlemen, this is the last time we shall meet together in a room formally, and I think we cannot separate without giving expression to our high appreciation of the very able manner in which the President has conducted the proceedings of the Association at this Meeting. I have been exceedingly pleased, as I am sure you must all have been, at the great amount of attention he has given to us, and the great desire he has had all the way through to make the Meeting thoroughly interesting and thoroughly useful. I am sure the day we had out yesterday was most delightful, and we must be aware that we could not have seen all the works we saw yesterday, especially at Bootle, without a great deal of foresight and work on the part of our President; and I am sure you will vote him your cordial thanks for the great attention he has shown to us. Of course our thanks are also due to the Corporation for the use of the Council Chamber, and for the very hospitable manner in which the officers were received—which, of course, was a recognition of the Association—yesterday, at the Mayor's banquet; but I will confine my observations now to the recognition of the manner in which the President has conducted our proceedings on this occasion, for which I beg to propose to him a hearty vote of thanks.

Mr. ASHMEAD (Past President): I have very great pleasure in seconding that proposition. I can only say for myself that I have been very much interested, indeed, in all I have seen in Liverpool, and very much pleased with the handsome way in which we have been met by the President.

Mr. ANGELL: As the President cannot put that to the Meeting himself, I will put it, and I am sure it will be carried unanimously.

The PRESIDENT, in reply, said:—Gentlemen, it has given me the greatest pleasure to see you here. I may say I have been for the last two months exceedingly busy, or, I believe, I might have done more for you, but that can't be helped. I am exceedingly glad you have thought it worth while to come to Liverpool, and I hope that some few things may have been of interest to you. Mr. Lyster's work, no doubt, must have been. I only wish I could show you anything half so interesting. I will endeavour, as I have said before, to do my best to the Association, and so far as I possibly can attend the District Meetings, I will.

Mr. LEMON (Past President): I have very much pleasure in proposing that the best thanks of this Association be given to the Mayor and the Finance Committee for their kindness in placing this room at our disposal, and for granting us the facilities they have. I am sure it is very satisfactory to the Association to see that various municipal bodies are now giving us such a cordial welcome, and are realising the fact that it is really to their interest, as Corporations, that their officers should have these means of extending their information. In fact, I may say that the Corporations are now alive to the fact that the more information their officers can obtain the better for the municipalities.

Mr. Vawser (Manchester and Warrington): I have great pleasure in seconding the proposal. I know the Mayor takes a great interest in the proceedings of this Association, and would have been present with us a longer time than he has been if his official duties would have permitted. We also saw here yesterday amongst the visitors two or three of the most distinguished Members of the Corporation, and I am sure we shall be all glad to find that Members of the Corporation, individually, as well as the Corporation as a body, take such a warm interest in our Proceedings.

The resolution was carried unanimously, and the proceedings terminated.

SUBURBAN HOUSE DRAINAGE AND WATER SUPPLY.*

By ROBERT VAWSER, C.E., Warrington.

I propose to describe very briefly the drainage and water supply at a large detached mansion in Cheshire, the residence of about forty or fifty persons. An outbreak of fever was the immediate cause for undertaking the works, and for the same reason the remedy was as thorough and complete as possible, and nothing that prudence could suggest to prevent a recurrence of the outbreak was neglected.

An inspection of the premises revealed many serious defects.

Some of the drains were brick circular drains; some had inverts and covers of stone with brick sides; they were generally 3 feet in diameter or 3′ 0″ × 2′ 6″ square, and had been altered and extended from time to time, and were irregular in direction, size, and depth: they were nearly filled with accumulations of sewage sediment, and in many places were under the buildings. The waste-pipes and several grids in larder, kitchen, and cellar were untrapped; the floors were honey-combed with rats, and there was practically no obstacle to the uncontrolled escape of sewer gas into the living apartments.

Most of the water-closets were new and in good working order; their soil-pipes were ventilated at the top by 2-inch pipes, but they communicated direct with the sewer, as also did the waste-pipes from wash-bowl, urinal, and housemaids' closets, these latter had lead syphon traps under the basins.

In designing the new drains, very great care was taken to prevent the escape of sewer gas into the house, and wherever a drain approached the house its continuity was broken by a water-trap and ventilator. All the old drains were taken up, the mud removed from under the house, and the space made good with clean earth or concrete; the rat-runs and useless drains were destroyed.

The clean water draining from the cellars, together with the overflow from cisterns and tanks, has been taken off by a special drain; the sewage is collected separately into 9-inch stoneware pipes, and purified on a small plot of land carefully underdrained and planted with comfrey, a very prolific plant, well suited for sewage cultivation, and as food for cattle.

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* This paper, written for the Liverpool meeting, was handed in and taken "as read," consequently there was no opportunity for discussion.

Near the centre of the main buildings three water-closets, a wash-bowl, urinal, and three sink waste-pipes discharge at the same place; these have been conducted into an "Edinburgh trap," the object of which is to stop the direct flow of sewer gas, by a water-trap, and to admit fresh air at the base of the soil and waste-pipes; the ventilation of these pipes is further ensured by continuing them at their full size to the roof. The drains have been ventilated by some of the rain-water spouts, and by special ventilators in open places. The waste-pipes from kitchen, laundry, &c., have been taken through the outside wall, and discharge on the top of trapped gullies; many useless grids both inside and outside the premises have been dispensed with.

The water supply was found to be very inferior; it consisted of surface water collected on cultivated land, and was otherwise polluted; it was consequently abandoned, and a better supply sought elsewhere.

The mansion is situated over the red marl in which the salt deposits of Cheshire are found; the surface is covered with a great thickness of drift sand and gravel. It occupies an elevated position, and is surrounded by a considerable area of table land, which upon examination was found to contain an abundant supply of pure water fit for every domestic purpose; a cutting having been made in the slope leading from the table land, a flow of 9 *gallons* per minute was quickly yielded, and it was ascertained this could be increased to almost any reasonable extent.

The level of the cutting yielding this water is so much above the valley contiguous to it, that it was found practicable to raise all the water required for the use of the mansion by hydraulic power: this is effected by one of Douglas' hydraulic rams, placed in the valley about 15 feet below the spring; the ram is 80 feet below the tank on the roof of the mansion; it has required no attention or repairs, and has supplied a continuous flow of water, at the rate of 1000 gallons per day, for the last six months.

The roof water from a very large area of slates and lead is likewise collected, affording an ample supply for every purpose.

It was at first expected steam or horse power would have been required to pump from some distant source, and the discovery of a copious supply so near at hand was made almost by chance, the application of this discovery may possibly sometimes prove the solution of one great difficulty in rural districts: (the water supply to small communities). Parliament fixes the value of a supply of water to a cottage at 2*d.* per week, which will shortly be increased to 3*d.* per week. It is difficult to work within this limit, but an apparatus such as described would supply a group of cottages or a mansion at a very trifling expense.

Its great merit is that no permanent expense is incurred, the apparatus really requires no attention, and will work continuously if left alone.

The Local Government Board urgently exhorts local authorities to improve their supplies of water, but the prices legally chargeable to consumers are seldom remunerative if costly engineering undertakings are forced upon small communities. The water resources of the country have lately been prominently discussed, and the opinion appears to prevail, that relief must be sought in the development of local resources, rather than in colossal national undertakings.

One reason for presenting this paper is to direct special attention to the question of house drainage, a subject often neglected by the engineer, who not unfrequently devotes his entire attention to the main and outfall works, and neglects minute details. It should never be forgotten that however important and interesting the outfall and main drainage may be, they form but a small portion of the ultimate cost; and the health of the community, which is the sole object of all sewerage undertakings, is influenced less by them than by details that are often overlooked.

People living in cottages are generally less exposed to infection from sanitary defects than those in houses of the better class, where every water-closet, bath, and untrapped cellar drain, is a source of constant danger. The best and only security against danger from these is a continuous current of fresh air through the soil and waste-pipes; a 1-inch or 2-inch ventilator at the top of the soil-pipe is practically useless; every soil-pipe should be quite open at the top, and have an equal inlet for fresh air near the bottom, and should be kept outside the house if possible.

The cellar drain when connected with a common sewer should have a water trap and ventilator just outside the building, in addition to the gully within, and the slopstone waste-pipe should not be laid direct to the sewer, but to the top of a trapped gully outside the building.

It is most important that the execution or workmanship of all drains or other sanitary appliances should be of the best possible; on no account ought works of this nature to be left to the discretion of the least unintelligent workman, as is too often the case: care is necessary to ensure uniform and sufficient gradients, this is quite as important in small as in large works, and should be jealously watched; every pipe should be ranged or boned in, and laid at a gradient proportioned to the size of the pipe and the flow of sewage along it. As a general rule, house drains are too large, a 9-inch pipe is sufficient for almost the largest mansion, or a village say of 1000 inhabitants, provided the gradients are good and surface water excluded from the drains.

An endeavour has been made to fulfil these conditions in the works forming the principal subject of this paper. The details can hardly be described at greater length without the aid of diagrams.

If we consider the condition in which the mansion was found, and in which other residences are known to be, it becomes a matter for reflection whether the system of inspection by local authorities is carried far enough. In new buildings disgraceful blunders are sometimes perpetrated through ignorance or neglect; and we have an accumulation of such blunders as a legacy from an age when sanitary measures obtained but little attention. The condition of the new offices of the Local Government Board at Whitehall may be taken as an instance of the former, and Marlborough House of the latter class.

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DISTRICT MEETINGS OF THE ASSOCIATION.

DISTRICT COMMITTEE MEETING AT DERBY.

A District Committee Meeting of the Association of Municipal and Sanitary Engineers and Surveyors, was held in the Guildhall, Derby, on Friday February 21st, 1879. Mr. G. F. Deacon, President, in the Chair, and there were present Mr. C. Pritchard, Vice-President, of Warwick and Westminster, Hon. Secretary of the Midland Counties District; Mr. C. B. Ellice-Clark, Hove, Hon. Secretary of the Home Counties District; Mr. C. Dunscombe, Derby; Mr. G. Thompson, Derby; Mr. W. B. Bryan, Blackburn; Mr. J. Lobley, Hanley; Mr. C. L. Stephens, Leicester; Mr. R. Vawser, Warrington and Manchester, Hon. Secretary for Lancashire and Cheshire District; Mr. W. Batten, Aston, Birmingham; Mr. J. Cartwright, Bury; Mr. J. S. Eayres, Newcastle; Mr. S. G. Gamble, Grantham; Mr. J. Mitchell, Hyde; and Mr. C. E. Buchanan Tudor, Goole.

The Minutes of the Wolverhampton Meeting were read and signed.

The President then said: The next business is the appointment of Honorary District Secretary. As you are aware, Mr. Pritchard has acted in that capacity with great ability for some time past, and I have no doubt he will be willing to again place his services at your disposal.

Mr. Stephens: I shall be happy to propose a vote of thanks to Mr. Pritchard for his past services, and to request that he will continue his kind attention to the business of the Association.

Mr. Eayres seconded the proposition, which was carried.

The President: Mr. Pritchard, we are all obliged to you for the interest you have taken in the Association. I believe much of its success is due to your exertions in the past, and I hope your interest will be unabated in the future.

Mr. PRITCHARD: I am greatly obliged to you, gentlemen, and I will do all I can to promote the success of the Association.

Letters were then read from absentees.

The PRESIDENT said: Gentlemen, I am very pleased to meet you once more at a District Meeting, and I only wish I could feel, as an officer of the Association, that the management of it had been all that it ought to be. Since I was elected President, I have received a great number of complaints from District Secretaries and from ordinary Members of the Association with respect to the absence of printed reports of the Proceedings, and also with reference to certain other matters connected with the District Meetings. It has appeared to me for some time past that there has been a link wanting in the management of the Association—District Meetings have acted without proper communication with the institution at large—and altogether the conduct of the Association is not organized in the best possible manner. With respect to one great cause of complaint, the fact that the Proceedings are not published as soon as they ought to be, I have only to refer to the circumstance that there now lies before me an uncorrected proof of the Proceedings of the Meeting held in July of the year before last. This is the first time I have seen an account of the Proceedings of that Meeting in print. It is scarcely necessary for me to make another remark on that point, for it must be patent to every Member that if the Association is to continue to have any weight whatever its Proceedings must be published at the proper time. The matter has not been overlooked by the Council. A Meeting has been held this morning, and a resolution passed, requesting the President to arrange with the Hon. Secretary, for a Council Meeting in London to take the whole matter into consideration, and I can only express the hope that those Members present, who have an opportunity of seeing other Members of the Association from time to time, will let it be generally known that the present state of things will not be permitted to continue if the Council can correct it. We shall have an early Meeting in London, when I hope some definite settlement will be arrived at, and some arrangement made by which the Proceedings will be issued within a very short time after each Meeting.

Mr. E. B. ELLICE-CLARK said, Without wishing to take up your time with discussing a subject that may appear to be outside the professed objects of this Association, it is my duty to call your attention at this, the earliest available opportunity, to the programme of the recently-established Sanitary Institute of Great Britain. At the risk of detaining you for a longer period than you could wish, it is necessary for me to inform you of the constitution of the Sanitary Institute. It is, I believe, the outcome of a meeting held some years ago in Birmingham, under the presidency of Mr. Chamberlain, the then Mayor; the idea of forming a Public Health Association fell through, but the subject was taken up by Dr. Richardson, and several other medical men of eminence, and the Sanitary Institute was inaugurated at a meeting numerously and influentially attended by medical men and others. It was urged, as it has been at similar meetings for a quarter of a century past, that for the Sanitary Acts to have any decided results, the mass of the people must be educated up to them; that the existing ignorance on sanitary matters was deplorable, and merited the gravest attention of all classes of the community. The tone of the meeting was a very right and proper one; those present decided to form an Institute for the advancement of Sanitary Science; the want of such an Association has pressed upon all those who have been engaged in prosecuting the Sanitary Acts, and has been frequently urged at the Meetings of this Association.

Eleven Borough Engineers joined the Institute, believing it would accomplish a great work in disseminating sanitary knowledge. I must confess that when I saw the Institute determined to examine Local Surveyors and Inspectors of Nuisances, it appeared to me the Council were travelling outside the professed objects of the society, but as few candidates presented themselves, I concluded it would die a natural death so far as examining Surveyors went, but during a controversy between the 'Builder' and the Registrar of the Institute, some of us were surprised to read in a letter from the latter, that "the chief work of the Institute consisted in the examination and granting certificates of competence to local surveyors . . . . a work of great public importance that did not come within the scope of any other society." This letter was followed up by an announcement to the effect that the Council of the Institute had determined to apply for a Royal Charter of Incorporation—as one may presume, to give the Institute a position amongst the Societies of the day—and, as we were informed in a circular, to facilitate the examination of Local Surveyors. Now one would have thought that if any examination to test the qualifications of Local Surveyors were needed, the proper body to conduct these was the Association of Municipal Engineers. It is a matter of the greatest regret that so badly has the Association been managed that this, with many other matters properly pertaining to it, has been overlooked. As the Association did not take the matter up, I personally addressed the Borough Surveyors of the country; informing them of the proposition of the Sanitary Institute, and requesting them to give their opinions on the subject if they could not attend the meeting.

But I am sorry to say only a few attended, and the discussion went all one way. I did not get a seconder to my motion, and a resolution was put from the chair to the effect that it was essentially necessary town surveyors should undergo an examination before they held office, and the right body to examine them was the Sanitary Institute of Great Britain. That startles all of us when we come to hear it, but when we know how the Institute is constituted, and what the membership consists of, we are still more startled. There are 340 members, some ladies being amongst them, and there are 24 engineers, including 10 town surveyors who belong to it. Any person of either sex can become a member by paying his or her subscription. This is the Institute which proposes to hold these examinations, and it has gone so far as to ask men in our profession who have gained much eminence in it to subject themselves to these examinations. I will not give names, but I have received altogether 140 letters from Town Surveyors and ex-Municipal Engineers, and with one exception they think that it would be a mistake to delegate to a self-constituted body like the Sanitary Institute work which properly appertains to the Association of Municipal and Sanitary Engineers. When I produced these letters at the Meeting, they thought I had got up this agitation, and said of course Town Surveyors would be against any examinations. But that does not follow, all Town Surveyors are not against examinations. There is certainly a difference of opinion as to whether examinations are necessary or not. For my own part, however, I think they are totally unnecessary; and if this was the proper occasion could bring forward arguments, which I think would demonstrate most conclusively that an examination is no test of a man's ability. I believe, to go to the greatest engineer of modern times, George Stevenson, this is proved, for he would have found the greatest difficulty in passing an examination. It is quite true that two of the learned professions—law and medicine—have for centuries only admitted into their body those who have passed certain examinations; but engineers are a different class from medical men or lawyers.

Supposing, for the sake of argument, we were to admit that an examination ought to be passed, is the Sanitary Institute the right body to undertake the work of examination? If we admit the necessity, let us at least have the proper persons to conduct these examinations. There is not a single Municipal Engineer on the executive. There are, however, two engineers, and most of the other members are medical men; medical men of undoubted eminence, such as Dr. Richardson and Professor Corfield, but I say that Dr. Richardson, and other gentlemen of like eminence in their profession, with their metropolitan practice and notions, have not the means of knowing what a Town Surveyor ought to be. They know nothing of the difficulties, which might seem small things to a large mind in London, but which are great things in provincial towns, and prove a stumbling-block for twenty-five or thirty years to sanitary matters in small towns. I therefore say it is quite impossible for a body of that sort to prepare such a series of questions which, answered correctly, would prove a candidate had proper qualifications for the office. The Board of Examiners have put certain questions to the Town Surveyors who have submitted themselves for examination, but I should amuse rather than instruct you if I were to read them. One question which was put on a recent occasion was: "If a bad smell is found to come from a sewer ventilator, what steps would you take to remedy the nuisance?" I will undertake to say there are twenty answers which it would be proper to make to that inquiry. Most of the questions put might be answered by any tyro who had been a couple of years in the office of a surveyor of a large borough, but Dr. Richardson, who is President of the Committee of Council, said that although the questions put were very simple, and might be answered by such men as I had described, several men holding the position of Town Surveyors had failed to pass the examination. I have no doubt whatever that is the truth, for there are a large number of men holding appointments under the Public Health Act, who are totally unfit and incompetent; but I cannot see that an examination of this sort will tend to raise the status and the necessary practical knowledge of Town Surveyors. There are many districts where the salary of Town Surveyors ranges from 20*l.* to 30*l.* a year. I know of one who has been lately appointed at a salary of 30*l.* per annum, and I know of a place where you might have seen on a sign-board, "A. B., Coffin-maker and Surveyor to the Local Board." This man received 15*l.* a-year as the emolument of the office. While, therefore, such sums as these are paid and such men hold office, I desire to know which of us would enter with them for an examination by the Sanitary Institute.

What, however, I wish particularly to call the attention of this Association to, is the unwarrantable interference with our privileges on the part of the Sanitary Institute of Great Britain. If examinations are necessary, this Association of ours is the body to conduct them. I should therefore like the Council to consider the matter, and with that object in view I now propose "That the attention of the Council be called to the fact that the Sanitary Institute of Great Britain propose to apply for a charter, and that they be requested to consider the expediency or otherwise of opposing that portion of such charter as relates to the examination of Surveyors."

Mr. C. **Dunscombe** seconded the proposition.

The **President** said: I do not think it is necessary for us to discuss this subject here. Mr. Ellice-Clark has put the matter before us from his point of view, and though we may not agree with all he has said, we must agree that the Sanitary Institute of Great Britain is not the proper body to conduct these examinations.

Mr. **Bryan** said a most important matter has been introduced by Mr. Clark. There are many grades of engineers and surveyors in this country, for as you know in many country districts the local blacksmith or stone mason is appointed surveyor, while in others they manage without a surveyor.

The motion was then carried.

The Association then visited several works in the town, and in the evening the Members dined together at the Midland Hotel. Amongst the guests were the Mayor of Derby, the ex-Mayor, Mr. Alderman Longdon, J.P., Mr. Councillor Hobson, and several leading Corporation officials.

DISTRICT COMMITTEE FOR LANCASHIRE AND CHESHIRE.

The ninth Meeting of this Committee was held in the Town Hall, Wrexham, on Saturday, 21st June, 1879. There were present Mr. Pritchard, Warwick and Westminster, Vice-President; Mr. Thos. Thornburn, Birkenhead; Mr. R. Vawser, Manchester; Mr. J. Lobley, Hanley; Mr. H. Royle, Stretford; Mr. G. Cole, Hereford; Mr. J. T. Eayres, Newcastle-under-Lyne; Mr. J. W. M. Smith, Wrexham; Mr. W. Blackshaw, Congleton; Mr. T. T. Allen, Stratford-on-Avon; Mr. E. B. Smith, Oswestry; Mr. J. Galsworthy, Aldershot; Mr. Biddle, Bootle; Mr. R. Hughes, Rhyl; Mr. Geo. Watson, Crewe; Mr. T. Sunderland, Blackpool; Mr. J. H. Burton, Audenshaw; Mr. J. T. Earnshaw, Ashton-under-Lyne; Mr. Richardson, Birkenhead; Mr. Clement Dunscombe, Derby; Mr. G. E. Thoms, Wolverhampton; Mr. G. Dickenson, Leigh; Mr. J. Richards, Burslem; Mr. T. Londin, Warrington; Mr. John Wilson, Bacup; Mr. Trapp, Manchester.

Visitors:—The Mayor of Wrexham (Isaac Shone, Esq.); Lieut.-Colonel Jones, V.C., Wrexham; Mr. Geo. Hill, Wolverhampton; Mr. F. D. Gibbons, Wolverhampton; Mr. J. H. Kidd, Wrexham; Mr. D. C. Davies, F.G.S., Oswestry; Mr. A. C. Baugh, Wrexham; Mr. Alfred Cole, Hereford; Mr. Joseph Hartley, Leigh; Mr. Councillor Roberts, Ludlow; Mr. C. Hughes, J.P., Wrexham.

The Secretary said he had received a letter from the President (Mr. Deacon) stating that he could not possibly be present. In his absence Mr. Pritchard, the Vice-President, would naturally take the chair.

Mr. Pritchard, having taken his place, said it gave him great pleasure to be in what he thought he was quite right in saying was one of the most important towns in North Wales, and especially under the auspices of his worship the Mayor. He was glad to see so large a number of Members had come such a distance to attend on that occasion, but he must express his regret that the worthy President, who had given such attention to the Presidential chair during his year of office, was not there, and they must all regret his absence. Without saying any further remarks he would call on their indefatigable Secretary to kindly read the circular convening the Meeting. Some little businesss would afterwards be transacted, and the Mayor would then kindly explain to them his pneumatic sewage system, diagrams of which they saw on the wall.

The Minutes of the last Meeting, held on the 24th of May, in Southport, were then read.

Mr. SHONE prefaced his description by saying that he was very glad to meet them there that day, and also that they had done him the honour to come and investigate this new system of sewerage which he had invented. He did not know that there was a body of men in the United Kingdom that he could be more pleased to see than the Members of that Association, because their work had everything to do with sanitary questions, and his was eminently a system which had to do with sanitary questions. He did not know whether many of them were aware that he read a paper upon this system at the Stafford Meeting of the Sanitary Institute of Great Britain. At that meeting he stated what were the leading features onnected with the gravitating sewerage system and with Captain Lieurner's pneumatic system, those being then the only systems which were in existence, or known to English sanitary engineers. He entered into calculations previous to reading that paper to show that economically and hygienically this system would compare with any other which had yet been introduced to his notice at that time. He had not, however, the practical data whereby to judge of its efficiency which he had that day. However, previous to writing that paper he had resorted to experiments in pumping water or ejecting water by compressed air which satisfied him that he was justified in drawing the conclusions which he gave in that paper. If any of those present cared to read the Transactions of that Institute they might be found in a special number of the 'Sanitary Register.' They would then understand what he referred to now. He took it that the gravitating sewerage system was an excellent system, provided the conditions under which it could operate successfully were fulfilled, but he maintained that those conditions, in the majority of instances, could never be fulfilled, and especially so in flat districts. He said it emphatically, and he was sure there was no engineer present who would deny what he said, that the insanitary results which had occurred from the general application of the gravitating system were a consequence of the injudicious application of that system. He had had the curiosity to calculate what size sewers would be required, say, for a population of 10,000 people, assuming that the sewage proper was dealt with. Take Wrexham for instance, which had a population of about 10,000. Now it had been the habit, as they were aware, when an engineer was called upon to devise a sewerage scheme for any district—it had been his habit and his instruction—to provide not only for the present population—that would be in this case 10,000—but also for a future population, and this population might be twofold or threefold of the present population, according to the judgment and calculation of the engineer. He would of course take into consideration the past and future probable growth of the town, and he had no hesitation in saying that in the absence of any such means of sewerage transport as he proposed to introduce to them, that some such calculations as he would indicate would be entered into for sewering a town containing a population of 10,000 people. Assuming the small quantity per head per day to be 15 gallons, and allowing one-half of this quantity to flow in seven hours, the quantity per minute would be equal to 28·57 cubic feet. Assuming that this population resided on a flat district, and the outlet was into the sea, on the gravitating system the engineer would have deep cuttings and get what gradients he could under the given conditions. Supposing he could get 10 feet to the mile, that would do it. Under such circumstances, a pipe to do duty would have to be 7·5 inches in diameter, but if in addition to the 15 gallons per head per day he had to provide for rainfall, then, assuming the population to live on 250 acres, and the maximum rainfall to be a quarter of an inch an hour, and that the drain should be of such a size as to take an eighth of this, the quantity per minute to provide for would be 472·66 cubic feet. Supposing the gradient to remain the same, he would require a pipe 22·92 inches in diameter. Then if the sewage was to be flushed by the rainfall, they had together a quantity of 501·23 cubic feet per minute, and they would thus require a pipe of 23·5 inches in diameter to take the sewage and rainfall from a population of 10,000 residing in an area of 250 acres. He might tell them that he had in this instance calculated the probable population that would exist in a town like Wrexham, growing as Wrexham did the fifteen years preceding the date of the last census. He had calculated the increase geometrically, and he found that the probable number would be 27,716 in sixty years; and pursuing the calculations the same way as he pursued them to ascertain the maximum quantity of duty for the pipe to perform, he found that the total quantity of sewage proper—reckoning 15 gallons per head per day—would be 66,278·4 cubic feet. Then there was the rainfall for that population. Assuming the area on which the population lived to increase in the same ratio, they would have about 700 acres at the end of sixty years; and allowing a quarter of an inch rainfall, the total quantity would be 1323·34 cubic feet per minute, and the outfall sewer 34·6 inches in diameter. Taking the rainfall and sewage together, they would require a pipe of 35·4 inches in diameter. That, he took it, would approximately be the size of the pipe which they would lay down for the accommodation of a population of about 10,000. In fact the pipes would be larger, as the engineer would lay them down and assume them to run half full. They knew perfectly well what that would mean so far as the sanitary element was concerned. They provided, in the first instance, under instructions perhaps from the Local Government Board, a pipe of 35 inches, say 3 feet, in diameter, to do duty for a pipe of 7 inches in the first place. He meant to say that a pipe of 7 inches would suffice to take away the sewage proper of 10,000, but under the present unfortunate state of things, and which has led to such insanitary results, engineers were obliged to provide a pipe 3 feet in diameter, and of course the larger the invert pipe the greater the liability would be to deposit. When the minimum flow of the population had passed into the 3-foot pipe, what followed? Why deposit, and then noxious gases resulted; then the engineer provided manholes, &c., by which this foul gas which was generated might escape into the street and annoy and poison passers-by. That was practically what was being done in the country now, and which was the necessary state of things in the absence of pumping such as was now being resorted to in Berlin.

He understood, by reading the report of the Sewerage Committee appointed by the Local Government Board to investigate the manner of treating sewage in foreign countries, that in Berlin they had half a dozen pumping stations, each of which was estimated to cost 50,000*l.* and to these pumping stations the sewage was made to converge. This approximated to the system he wished to introduce to their notice that day; but by his system, instead of having to erect expensive pumping-stations at each point, one engine would suffice. He did not say that that would be the policy which he would pursue in the case of Berlin, but it sufficed for his illustration. They might get these half-dozen pumping-stations actuated properly by one engine,—that is to say, they would not require boiler, steam, and attendance, at each station. One engine-station would suffice for the half-dozen pumping-stations. There was another point that necessarily followed the introduction of such a system of pumping as that adopted in Berlin. Assuming the engines were beyond the capacity of the sewers to fill the pits, the engineer must be careful to start the engine when the pit was full, and to stop it again when empty; but he had an arrangement by which none of the power which he employed for ejecting the sewage was wasted,—that is to say, it would only operate when the ejector was full, and no power would be used beyond that which was necessary to eject the quantity the ejector would contain. His motor was compressed air. It might serve his purpose now just to draw their attention to a few statements made in a little book he had just purchased from America. It was a little book entitled 'Transmission of Power by Compressed Air,' by Robert Zahner, M.E., published in connection with Van Nostrand's Science Series. It was a very interesting little book, and it conveyed so thoroughly his own views with regard to the use of compressed air, that by their leave he would just give them a short quotation from it:—

"For transmitting power to great distances, shafts, belts, friction-wheels, and gearing, are clearly out of the question. The practical incompressibility and want of elasticity of water render the hydraulic method unfit for transmitting regularly a constant amount of power; it can be used to advantage only where motive power, acting continuously, is to be accumulated and applied at intervals, as for raising weights, operating punches, compressive forging, and other work of an intermittent character requiring a great force acting through a small distance.

"Compressed air is the only general mode of transmitting power; the only one that is always and in every case possible, no matter how great the distance nor how the power is to be distributed and applied. No doubt as a means of utilizing distant, yet hitherto unavailable, sources of power, the importance of this medium cannot be over-estimated. But compressed air is also a *storer* of power, for we can accumulate any desired pressure in a reservoir situated at any distance from the source, and draw upon this store of energy at any time; which is not possible either in the case of steam, water, or wire-rope. Larger supply pipes are required for steam or water transmission.

"There is every reason to believe that compressed air is to receive a still more extensive application. The diminished cost of motive power when generated on a large scale, when compared with that of a number of separate steam-engines and boilers distributed over manufacturing districts, and the expense and danger of maintaining an independent steam power for each separate establishment where power is used, are strong reasons for generating and distributing compressed air through the mains and pipes laid below the surface of streets, in the same way as gas and water are now supplied.

"There can be no doubt that the great waste of energy that to-day accompanies the use of compressed air is due, not only to sickly design and faulty construction of machines, but very largely also to the general ignorance of the principles of thermodynamics.

"There is no doubt that a permanently located air-compressing plant, established on a large scale, and designed on principles of true economy and not with reference to cheapness of construction, would supply power at a much less cost than is supposed. Besides, there are many natural sources of power, as water power, which could by this means be utilized, and their immense stores of energy conveyed to the great centres of business and manufacture."

Mr. Shone said he entirely agreed with the statements here made, and those who wished to inform themselves further on this most interesting subject could easily do so by acquiring this little book, which could be purchased for 2*s.* 6*d.* He would now ask their attention to the system by which he proposed to treat sewage, with a view to make habitable areas practically unobjectionable, sanitarily speaking. A well-known gentleman, Dr. Richardson, had an idea that he could build a city which he would designate "The City of Hygeia." With all due deference to that gentleman, he thought those present would agree with him that the day was somewhat far distant when anything of that kind may be looked for; but he respectfully told them that his belief was that if this system of his were put down in any town—it mattered not what its configuration, whether flat or undulating—they could always plant down an ejector in any suitable position they might find which would command the sewage to flow into the ejector. That was to say, by his system they could divide a town—whether of 2000, or 100,000 acres, with a population sparse or dense—and plant ejectors in such situations that the sewage should flow at the necessary velocity through the pipes as would make the pipes self-cleansing. He would here impress upon them this important fact which all engineers were agreed upon, that it was absolutely necessary, if they would have sanitary laws observed, that in small pipes the sewage when once introduced to them should flow through them at a velocity of not less than three feet per second. This ought to be a *sine quâ non* with engineers, a *canon of hydraulic law.* All were agreed that if they could bring about such a condition of things as this, they prevented the generation of gases, prevented silt from depositing in the pipe, and necessarily prevented decomposition. In theory this seemed very nice, but he would venture to say that they would agree with him, when they saw the ejector that he had got down on his friend, Lieut.-Colonel Jones's farm, that it was a practical thing. It was not of that class of article which they could well persuade themselves would get out of order. The automatic gear connected with the ejector was so extremely simple and so strong that he declared that he did know how it was to get out of order.

Mr. Shone then proceeded to describe the working of the ejector aided by large sectional diagrams. He had added a reservoir, for the sake of showing that in case of any mishap in connection with the automatic gear, or supposing they wanted to stop it, the sewage may accumulate temporarily in this reservoir. An engineer, a very eminent man, said he did not see how he was going to get it into the ejector, and after that how he was going to get it out. Others had said, Suppose a brick or a baby should get into it, cannon-balls and the like, which, of course, were not sewage. Bungs, corks, &c., may get through and operate prejudicially, but, of course, by an arrangement of the description named any floating matter would be intercepted by the diaphragm, and nothing but sewage could pass the pipe. However, since he had erected an ejector at Wrexham he had really done nothing to intercept the sewage. He had not even a grid on the face of the inlet pipe; he had not at all interfered with the sewage passing into it in a raw state. If a baby did happen to go in, it would go—but he was not aware that any such thing had passed into the ejector. As to the brick he felt quite sure it would not be carried down a gravitating pipe, but even if a brick did get into the ejector he believed it would be just as likely to get out again. All sorts of things, bungs, corks, leather aprons, dish-cloths, pieces of bedding, &c., had passed through, and he was quite astonished that such had never stopped it, and he would give any gentleman liberty to do anything he liked with it. The ejector he had fixed in Wrexham discharged at one operation 325 gallons, something like 52 cubic feet. The operation was very simple. The sewage passed down an inlet pipe, on the head of which was a ball which he would call the *vis-à-vis* of the one which they saw on the outlet pipe. When the sewage passed down the pipe it raised the ball from its seat, and then went on into the ejector. The difference between the specific gravity of the water and the ball was such that two or three inches of sewage would lift it. As it passed into the ejector and filled it a cup was filled by it; the sewage gradually moved up until it reached a cup at the top, which was inverted. When the sewage got underneath the inverted cup it lifted a lever attached to a valve at the top, which was thus moved, and the air admitted. The compressed air rushed on to the surface of the sewage, which it literally blew out. The moment the air reached the surface of the sewage the inlet ball fell to its seat, and the sewage could escape in no way except through the outlet pipe. The effect of the admission of air would, of course, be to raise the ball then on its seat on the outlet pipe, and the sewage would pass into the (it may be) sealed gravitating pipe, such as he had at the farm, where he ejected 325 gallons a height of 40 feet. There he would also show them how the air, after the ejection was over, passed through an exhaust pipe into a gravitating sewer, and then out at the outlet, thereby ventilating the same in a novel but, at the same time, most effective way. So they had really a novel way of collecting sewage from flat and undulating districts, and then ejecting it either under pressure to its required destination, or into any existing gravitating sewer. At Wrexham he had placed a *cul-de-sac* end sewer, which could be extended to any given district. By planting one of the ejectors in some situations they could eject sewage through a small pipe into another existing gravitating sewer, and thereby aid that sewer in doing its duty much better than it was now probably doing it, because in the majority of instances pipes at the head are so large that they would be much better by having introduced into them additional volumes of sewage. He could say nothing more at present, except that he should like those present to keep any observations they might have to make until they had seen the ejector at the farm, and see what was being done there, and, perhaps, after the statements he had made they would wish to examine the diagrams, &c., and after they returned they might discuss the matter in any way they pleased.

He desired them to be as frank to him as he had been to them. If the ejector was not perfectly practical no amount of statement he might make would make it so; if it was so no amount of criticism could make it otherwise. If any gentleman would like one of his circulars he would give him one. He also found that a paper read by Lieut.-Colonel Jones, at the Society of Arts, was pretty fully given in the 'Sanitary Register,' the organ of the Sanitary Institute of Great Britain. He had procured a number of these copies, and with his circular he would also give them one of them, and also Mr. Sturgeon's circular relating to the air-compressor which he had operating on the ejector. The Sanitary Institute of Great Britain intended holding a meeting in Wrexham on the 28th of this month, and he hoped he should have been able to have had one of those compressors there, but the manufacturers of them (Messrs. Twaites Brothers, Bradford) were not able to leave the engine, as he (Mr. Shone) was having an exhibition of a little ejector at the Royal Agricultural Show. Under the circumstances, the Sanitary Institute had decided to run an excursion to Wrexham on the 18th July, for the benefit of its Members and others who might be interested in the working of the Pneumatic Sewerage System, and on the 19th a meeting would be held, at which the system would be fully discussed.

The Chairman said, Without entering into any discussion, he thought, after the explanation they had had, that it might not be out of place if Mr. Shone were to add anything he might have to communicate about the cost of this scheme.

Mr. Shone said he proposed very shortly to issue a work upon air-compressing and air as a motor Such a work would, he hoped, exhaust the whole subject. It was a very difficult one to go into at a meeting of that kind, and one upon which he could only theorize; but he proposed to issue this book, which would furnish such information as was now asked for. With the little compressor he had pumped water to a height of 15 feet. In endeavouring to get the best conditions possible to test what he could do he had a reservoir, or receiver connected with the air-compressor, which would hold 25 cubic feet of water. He filled this reservoir and had placed into it a pipe the exact size of the air and steam cylinders. He got the pipe made of the *vera contracta* shape so as to create the best hydraulic results to run the water. He got the engine to go at so many evolutions, and he then cubed the air cylinder, and ascertained the result. He found that by this mode, even with this little engine—and they knew they could not get such economical results from a little engine as from a large one—but notwithstanding this he managed to eject the whole of that water, and the loss was about 10 per cent. The volume ejected was the exact equivalent of the volume of air compressed to the necessary power to operate upon the water, less 10 per cent. For the sake of showing what could be done on a large scale he entered into a calculation as to the capacity of the engines in the Powell Duffryn Collieries, where there were several large air-compressing engines. The quantity of air compressed by the largest of the engines was quoted by reliable authorities, and he tried to ascertain what number of gallons he could raise by that engine supposing he used it to eject water instead of pumping it. He found he could raise 5000 gallons 100 feet high for a penny, reckoning fuel to cost 10*s.* per ton, and assuming the conditions to be pretty much the same as those he resorted to with his little engine. Then his friend, Mr. Sturgeon, went into a calculation, and his statement was as follows:—If a compound condensing steam-engine were employed, with a "trunk air compressor," to compress air to fifteen pounds pressure per square inch (which would be all-sufficient for most flat towns), the quantity would be equal to 53,125 gallons per minute, raised one foot high, with one pound of coal. This was so far as he had gone into the matter of ejecting water on this system, but he would draw their attention again to the fact that supposing they agreed that it was desirable that the sewage should be separated from the rainfall—and most engineers would now agree that it should be, and his friend Lieut.-Colonel Jones had laboured hard in that direction—the question arose, how would they flush the drains? Under the present mode, when the sewers wanted flushing most was the time when the flush was not there to do its work, and if they had this economical motor ready at hand to do the work, they would have a great desideratum. He might say that at the Mont Cenis Tunnel very elaborate and practical experiments were resorted to to discover what was the loss of power by friction and leakage of the air. The tunnel was driven by compressed air. Rock drills were used, which were operated upon by air. The air main was seven inches in diameter. When the tunnel was four miles in length, they found that the loss of power of the air, which was compressed to 90 lbs. the square inch, was something like three and a third per cent., which was practically out of the question when they could have the air produced in the manner in which Mr. Sturgeon produced it. They decided leakage in this way. They closed the pipes and stopped operations for twelve hours, and the leakage was about three and a half per cent. They had an iron main hermetically sealed, and, after allowing high pressure to the air, the loss was only a matter of three and a half per cent.

The Chairman said the discussion would take place after the inspection of the works at the farm. They had also the opportunity of visiting one of the best and most celebrated sewage farms in the country, and one which Colonel Jones had successfully worked himself.

The Company then proceeded to Hafodywern farm to witness experiments made by the ejector, and to see fully and practically what the invention would do. The first point of interest was the engine-house, situated a long distance from the ejector itself. Here was a comparatively toy engine, and the remarkable thing connected with it was that though so very small it could compress sufficient air to work the ejector, quite a third of a mile away, and lift the large quantity of 320 gallons of sewage a height of 40 feet in a remarkably short space of time. Proceeding to the ejector the company entered the house temporarily erected over it and received a full and lucid explanation of all points connected with the mechanical part of the machine whilst it was in operation. Its simplicity of construction, its effective and certain work, and the noiselessness of its operations, were much commented on. Mr. Shone then conducted the party to the highest point of the farm to where the sewage was ejected, and the continuous and steady vomit quickly exhausted the contents of the ejector. They then passed down the farm to another temporary sewer which Mr. Shone had erected to show the applicability of the ejector to the purpose of pumping from a low level to a higher level gravitating sewer, &c.

A number of questions having been put and answered, the party proceeded to view as much of the farm as time permitted under the guidance of Lieut.-Colonel Jones, whose long and successful investigation and complete mastery of the principles of sewage-farming made him a most acceptable and profitable guide. The company expressed their high commendation of the general management of the farm and the excellent appearance of all the crops. The tanks and other matters in the open air having been thoroughly examined, the party entered the sludge drying shed, and were speedily interested and full of inquiries as to the mode of this procedure. The party then wended their way back to the Town Hall where a discussion on the objects at the farm took place.

The CHAIRMAN said they must all have been highly gratified at the ingenious works they had seen that morning, and also at the very fine sample of a sewage farm. Before going out it was thought desirable to first see the works, have an explanation, which they had most lucidly from Mr. Shone and Colonel Jones, and then after that to thank them. The proper time for that would shortly arrive, and in the meantime he was sure Mr. Shone and Colonel Jones would be pleased to hear and answer any questions which gentlemen might see fit to put. For the sake of convenience he thought a general reply should be given.

Mr. THORBURN (Birkenhead) thought they were very much indebted to the Mayor of Wrexham for inviting them there, and they had been amply repaid for their visit in seeing the very excellent and ingenious system which he had invented for lifting sewage and water without the direct agency of steam at each station. That the principle was ingenious and convenient and ready in working must be apparent to all. The only thing which appeared in his mind was the cost of the system as compared with steam. That an air-engine, put in a central position, would send the compressed air to any particular point was apparent to all, but whether that would be as cheap per 1000 gallons of sewage or water was a question they had not yet been clearly able to see. Probably Mr. Shone would be able to tell them something more about its cost in a short time. It was, after all, upon this that the success of such an invention must in the main depend. In reference to the practicability of compressed air for lifting sewage, he apprehended that the invention was more particularly useful for lifting sewage with a view to working land, or for improving the gradients in flat districts, such as Berlin, for instance. Southport had been mentioned also, and there he thought such an apparatus would be an inestimable advantage. Then looking at the question in another point of view, in reference to its application to large towns. Of course he need not tell the Mayor of Wrexham that to apply the system to large towns did not do away with the need of miles of sewers to convey the sewage from the houses to the district to be worked, and then as to the value of land and the inconvenience of fixing such an apparatus in the midst of a population. These were all questions which came in to be carefully considered before such a scheme could be adopted. He did not know that he should like, at this stage of his knowledge, to give any decided opinion, but he must confess that up to now he had not been able to discover that any machine, under the most favourable circumstances, would be a complete solution of the sanitary question, however much he might admire the ingenuity or the principle. They had not had an opportunity of comparing the expense of steam and compressed air. The question was whether, when worked out on sound commercial principles, it would be an advantage or not. That the apparatus might be of great advantage—such as in the case of Wrexham where the sewage farm land was situated at various levels—he thought in such a case the whole land which Colonel Jones so excellently managed, might be brought within the irrigation system by such a machine. Of course Colonel Jones could state what advantage that would be to him, and whether the land would pay for fixing such an apparatus as Mr. Shone had explained to them. They all wished Mr. Shone success and that he would overcome any difficulties in the way of his carrying out his ideas in respect to compressed air as a motive power, and enabling sanitary engineers to do away with excessive area necessary to provide for prospective population and for carrying away storm water. That they had arrived at the stage of separating water from the sewage he did not believe, but in small towns he thought such was more probable. Here the machine would come into most favourable operation. By separating the sewage from the rainfall they must necessarily be able to deal with the sewage at a smaller cost than if the two were mixed. There still remained the question of flushing the sewers, if they separated the rainfall. He did not take it that Mr. Shone's system was in competition with Captain Lieurner's, although in one sense it was. Captain Lieurner's system was a complete system, not only for lifting the sewage but working the whole net-work of sewers; and he took it that Mr. Shone's was more for overcoming natural difficulties of levels and thereby enabling parties to get rid of their sewage into the sea, or, in an inland town, of getting over the natural difficulties of the land. He thought the points he had touched upon were the cardinal points of the question, and he hoped they would lead to a lively and interesting discussion. In regard to the farm most of them had heard it explained several times, and he was sure it could not have a more energetic and painstaking farmer than Colonel Jones. He had spared no labour nor expenses in working the farm and bringing it to the state of perfection it was now in. It was probably a fair sample of a sewage farm, and it was in as good sanitary state as any farm he had visited. It was a very great improvement upon some of the former sewage farms which were a nuisance for miles around, but here they may sit down and dine almost under the sludge drying place.

Mr. J. Lobley (Hanley) said he would make a few remarks showing how this system might be adopted in particular instances. He would take, for instance, his own town. He had it in his mind to recommend it to his own town for those districts which lie very low. In regard to the other parts he still thought the system would not be applicable, and for this reason. The upper part of the town, where they were now building, was 300 feet above the other part. The sewer did not require a lift until it got to the intercepting sewer. When it got there and had to follow the valleys then it required to be lifted at a pumping-station. Taking the number of houses at 9000 they would require to lift the sewage of 8000 at the outfall works. No advantage could be gained by this system except at the outfall. At the outfall he did not think Mr. Shone wished to put his system into direct competition with steam power. From one direction of the outfall they had a few houses, in a hamlet, a mile away from the works, and in a second instance a few houses 1¼ mile away from the works. These houses were situated below the level of the intercepting sewer. He might deal with these by a low-lying sewer, but to have a low level sewer to drain a few houses would be very expensive, and then it would have to be pumped when it reached the outfall. So he thought this system would be quite applicable to this place. One village was 1¼ mile from the works and lay a few feet below them. One arrangement would be to construct a low-level sewer and then pump. Another would be to run along the valley and join an adjacent system. But they knew that in most of such cases they had to pay most unsatisfactorily for the accommodation, and if they could do it themselves it would be a great advantage. Of course there were difficulties in this matter, and one was the distance from the works. He had also thought of putting down a small gas engine, but it would necessitate a man to attend to it, but the system of Mr. Shone would not require a man. So it simply came to a matter of calculation of expense. There would be the long air pipe. If that could be put down for less than the sewer then it would be successful. He thought they might safely conclude from what they had seen that it would succeed admirably. Further the ejector would not require any land to be purchased for it. But of course the main point was the expense of the long length of air-main and then the expense of the ejector itself. He believed the ejector would be a most useful invention, and that there was a future before it.

Mr. Thoms (Wolverhampton) said it seemed to him that the pneumatic system under discussion would be chiefly valuable as a supplemental system, and that in a sanitary point of view this system presented special advantages, for in keeping the fæcal matter in motion and rapidly conveying it to its destination it prevents the formation of gases injurious to health, whereas in many ordinary gravitating sewers deposits occur owing to the small velocity of flow—due to flat gradients—and these deposits give off gases dangerous to the health of the district. Compressed air as a motor seems specially adapted to this system, although it proved a failure when tried many years since on the South Devon Railway. He was of opinion that the ejectors would answer best with the "separate system," but he did not see how the diaphragm would keep obstacles out of the ejector when there was a rapid flow of water. The ejectors, even as supplementary to existing systems, seemed to him to be extensively applicable. Assume, for instance, a large town of 4000 acres with 3000 acres drained to one outfall, leaving two or three low-lying districts undrained, each of comparatively small area, these isolated districts may be drained by the pneumatic system at much less cost than by the usual method. As to the farm, he was much interested in sewage farming, having the charge, so far as relates to the sewage, of a farm of 330 acres, and he might say that the two Members of his Sewage Committee, who were present as visitors, agreed with him that great praise was due to Colonel Jones for bringing the Wrexham Sewage Farm to such a high state of cultivation.

Mr. Dunscombe (Derby) said so far as he could see, the chief advantage the ejector had was the transmission of power to a distance and to the points required. For instance, it would be very beneficial in a supposed large area of 1000 acres in which, more than probable, at the higher level there would be an intercepting sewer of large capacity, and there was no reason, if sufficient fall could be obtained at the outfall, why that power, by the erection of a turbine at the high level intercepting sewer, might not be made the means of transmitting a power to the low level district, and pump the low level into the high level. In regard to the expense, they had not had much information upon it, and of course it was a matter of expense. The apparatus was certainly most ingenious, and reflected the greatest credit upon the inventor.

Mr. LOBLEY (Hanley) said he found that steam as a rule was most economical. Water power was so uncertain that it was not always found most economical.

Mr. VAWSER (Manchester, the District Secretary) thought it would be gratifying to Mr. Shone to know that no one had found any fault with his scheme. He did not know whether it was his (Mr. Shone's) modesty or not that induced him to say that his system was to deal with sewage only. It seemed to him that the system was equally capable of dealing with rain-water as with sewage. All of them there had to do with actual works of drainage, and all of them knew that however advantageous a duplicate system of sewers might be, theoretically it was exceedingly difficult to convince Boards that there was not a very great loss in adopting it. It was only the previous week that he suggested the partial adoption of the duplicate system, that is to say, taking off the storm-water falling on a broad country and within a short distance of brooks, and he had a painful recollection of the indignation it raised in the minds of several members present who thought that it was but a suggestion to increase the expenses of the works to his own advantage. Of course he could repudiate such a thing as that (The CHAIRMAN: Naturally), but if one introduced anything that was not ordinarily adopted it was always a difficult thing to get it adopted. Therefore he should suggest that Mr. Shone, instead of insisting that they must have two systems of sewers that he should try to show that the system he advocated was applicable to sewers as they existed. All of them would put in storm overflows and adopt all other means of getting rid of large quantities of overflow, and he really thought Mr. Shone should make it applicable to present arrangements. Colonel Jones took advantage of purifying the sewage, and said, "I must have it in a certain condition. I must not have surface water, and you must incur enormous expense to keep the surface water separate from the sewage, and you must deliver it to me in the most clean form for me to deal with." Now he considered it the duty of those who had laid themselves out to purify the sewage to adapt the work of purification to the existing conditions of the sewage. Many of those present represented manufacturing towns, and they knew very well that after they had taken away the water-closet and slop sewage in a small pipe, they had left a nuisance quite equal in extent in the other refuse of the town. They should take it that sewage consisted of all noxious matters in a town, let it arise from any source whatever. Unless people who undertook the purification of sewage were prepared to receive sewage in the condition in which they found it in practice, then it would not be of much use. Most people had now abandoned the idea of making money by sewage; the object was to avoid nuisance, and prevent further pollution. The whole question was, What can be done to be most beneficial at the least possible cost?

Mr. RICHARDSON (Tranmere) said another point was the saving of the cost of deep cuttings often necessary to get the sewage to flow to the outfall.

The CHAIRMAN then invited a few remarks from Mr. Sturgeon.

Mr. STURGEON said he should be very happy to give all the information in his power in regard to the air-compressing aspect of the question. On the other points it would be presumptuous on his part to say anything. In regard to economy, which was the principal point, Mr. Shone said the sanitary object was the principal one and the question of cost secondary; but he thought he could show that even on this score the balance was entirely in favour of Mr. Shone's system. The small pipes required to transmit the sewage, and the avoidance of deep cuttings, as one gentleman had pointed out, made such a saving in the first cost, that the utmost possible expense of compressed air, taking it at the most extravagant figure possible, if capitalised and added to the first cost of the works, would still leave the balance largely in favour of Mr. Shone's system. But without going into that, he thought he could show that a great deal of misapprehension existed in regard to the economy of compressed air. The very idea of it seemed to frighten engineers. From some remarks made around him at the Society of Arts he concluded that several of the members were startled at the idea of using compressed air to force sewage. In the first place, compressed air had been debited with a good deal of loss and waste of power which was due to the old-fashioned system of compressing air. Without going into particulars, modern improvements had overcome many of those defects, and the compression of air now could be effected very economically; but there were of course natural laws which could not be overcome, such as the development of heat in compressing air, which represented so much power lost, and the power expended in raising the pressure, which in Mr. Shone's system was not returned by any expansive action. When compared with the pump, the balance was largely in favour of the compressor system, for in the former case, in addition to the friction of the machine, &c., there was a body of moving weight brought into motion in one direction, then its momentum was suddenly stopped and the motion driven back into a contrary direction, and this destruction of force at every stroke must make a large deduction. When this deduction was duly allowed for, there was such a large amount to come off that the low pressure which was required in Mr. Shone's system showed the balance to be really favourable. In an example taken from the Powell Duffryn engine, and taking the work of the compressors and the power expended in the engines driving them as his data, he made out that for a population of 100,000, with an engine which indicated only 32 horse-power—a very low power indeed, he could raise the equivalent of fifty-nine and a half million pounds 1 foot high with a cwt. of coal. There were very few cases in which water power may not be utilized to compress air, and thus do away with the consumption of coal altogether. In many cases where there was a water supply to the town, and where it came with such a head that it was necessary to break it with reservoirs, there was no reason why that power might not be used to compress air, and thus supply the whole power necessary, at any rate a large proportion of it. Then another point was the letting of the sewage flow to one pumping-station. In many instances this may necessitate the pumping of the sewage from a lower level than need be if they distributed the ejectors, each ejector having only its own district to deal with. In regard to the loss of power in transmission through the pipes, he would mention the case of the tunnel in Massachussetts, where the power of the air compressed was 62 lbs. to the square inch at a distance of nearly three miles, and there was but a loss of very little more than 1 per cent. by loss and friction in the pipes. At Beckwell, in Derbyshire, an air-compressing engine was worked by a turbine to supply power to a lead-mine about three-quarters of a mile distant. Formerly they worked hauling engines by steam, but when they fixed the air-compressor they dispensed with steam altogether and used air power direct. The compressor and turbine were locked up in a little shed, and no one went near them except to renew the lubrication. He thought he had touched upon all the points brought up in connection with the question of compressed air. In America it was much more largely employed as a power than in

England; they were not so frightened of it as English engineers were.

The CHAIRMAN said he fully agreed with all that had been said. Nothing had been said, so far, against it, and he was desirous that some one would have raised some abstruse question that would have troubled Mr. Shone, but it appeared to have been so well thought out by him, and, if anything, he had not said quite sufficient in its favour. They were told this ingenious invention was to be the subject of discussion by the Sanitary Institute of Great Britain, but he was pleased to say that the members of the Sanitary Institute would hardly be so much at home with it as they were, and he thanked Mr. Shone for the privilege of being there that day. Before speaking in favour of the machine he should like to raise the question of costs. Mr. Shone was not in a position at the present time to give them the approximate cost. He took it that this was in competition either with steam or water power as a motor, and after hearing all the various opinions given he drew the conclusion that there were some very important points in favour of the ejector. One was, the removal of sewage without the necessity of any particular description of valve or piston. The complete absence of anything like momentum, &c., and the loss by escape and friction being so infinitesimal, only pointed to the conclusion that this description of pump—if they may so speak of it—must eventually compete with either steam or water power as a motor. Another point, which appeared to be almost lost sight of, was the ventilation of various sewers, which would be very beneficial indeed. One point raised was the one pointed out by Mr. Dunscombe, that the waste power at the outlets of the sewers, by the means of a small turbine, or something of that kind, should be used to lift the sewage from the lower level to that of the higher, and then gravitate it to the land for treatment in the ordinary manner. That appeared to be a point that had not been considered that day so much as he thought it would have been, and this was one of the points which Mr. Shone's modesty appeared to keep in the background. In his own mind he was perfectly satisfied that the only thing in competition with this was the pump with which they were acquainted—the "pulsometer"—and when they found that the radiation from the steam pipe was very considerable, and that they could not take it a great depth, it may never hope to compete with this system. A very great deal had been said about the separate system. One gentleman pointed out that sewage must really mean the whole of the contaminated water of a town, and he wished to know how the sewage of a town like Birmingham could be dealt with unless they took the water of the streets. The traffic was so great and the water so dirty that if they had a separate system of drains they must also have a separate purifying place. He maintained that it was necessary that sewage should include all contaminated water. It was the opinion of all modern engineers that where they could get a separate system for small districts it was a great improvement. He did not think he could say much more. The subject appeared to be very fully discussed, and there seemed to him to be a very important future for the ingenious apparatus, and he could not help saying that he wished the invention every success. In reference to the farm, that was a subject they had all been interested in. After seeing the working of these farms for fifteen years he did not hold the same opinions as he did. He believed that Colonel Jones was showing what could be done in regard to the utilization and purification of sewage, and he should like to hear from him a few remarks in regard to one or two points which he thought were of interest to all, viz. the number of years in operation, the quantity of land farmed, the maximum and minimum quantity of sewage, and the amount that could be dealt with, &c. He would now express his satisfaction of what he had seen at the farm, and his extreme dissatisfaction at what he had seen at the tanks. Modern tanks were now so made that the sewage was taken to the fallow land by simply opening a valve, and the tanks seemed to him to be the only drawback to the well-conducted farm they had seen that day.

Mr. Councillor Hill (Wolverhampton) said he had been delighted with the view they had had of the contrivance of the Mayor of Wrexham, and with the simplicity of its mechanical parts, and he thought that there were many uses to which it might be put in the future. He quite agreed with Mr. Shone, that where possible the rain water should be kept separate from the sewage. In Mr. Shone's system they would save expensive cuttings, and there would be no stagnation owing to the sewers being too large. He had also been very much pleased with the sewage farm, and the crops to his non-professional eye were in a very flourishing condition.

Mr. Shone, in reply, said the other day he looked over a blue book to see what sums were recommended by the Loan Authorities for the purposes of sanitary works for urban and rural districts for the year 1877, and he found that the several sums amounted to 2,690,516*l*. This was for one year, and he wanted to remind those present that they were the gentlemen associated with these various works, and the most important question was, whether the results aimed at by the expenditure of this amount were gained. He had no hesitation in saying that, so far as regarded the money spent in sewage works, instead of the results being satisfactory they were very unsatisfactory. Various gentlemen had touched more or less upon the question of costs. He would tell them that as yet it was impossible for him to furnish them with data as to costs; but allow him to tell them that he was to all intents and purposes practically acquainted with the sewage scheme which had been applied to Llandudno. He happened to possess everything in point of fact which was necessary for the engineer to know concerning it, and therefore, assuming himself competent to criticise, he would undertake to say that whereas in this case the actual costs incurred had been 40,000*l*., he would have undertaken under his system to have rendered that town sanitarily unobjectionable for 15,000*l*.; and he would satisfy Mr. Sturgeon, the Chairman, or any other engineer, that his calculations were correct, or he would pay the costs of the investigation. There was only a resident population at Llandudno of 5000, and the water supply was only about ten gallons per head, and the very maximum quantity which passed into these huge sewers would not produce a velocity of one foot per second. In regard to this system he would compete economically with any pump. They heard what Mr. Sturgeon had stated, and he did not say it because he was present, but he believed he was one of their most eminent authorities upon air-compressing machinery, in fact the only mechanical engineer he had met who could investigate the subject from beginning to end. His experience was valuable, and the statements he had made were most valuable, because they corroborated what he most believed in. In the case of Llandudno, instead of having these large sewers under the streets emitting noxious and dangerous gases, upon his system they would plant down an ejector and command the sewage to flow to it at the necessary velocity to make a pipe self-cleansing. He took it that this was most important. He had attended the meeting of the Society of Arts in 1875 as a deputation with the then Mayor. He thought that meeting was the first at which the Society touched upon sanitary questions. There were two days' discussions, and the committee appointed to collect evidence, after hearing what everyone had to say on the subject, came to the following conclusion, "That for health's sake, without consideration of commercial profit, sewage and excreta must be got rid of at any cost." In regard to cost, this system would be infinitely cheaper than any other, and as regarded efficiency there could be no question. He was glad to find that all of them agreed that this system was more certain in its action than the gravitating system. Even supposing that this was an expensive motor, and taking such into consideration, he would follow them into a place like Llandudno and say, Here instead of 40,000*l.* you would have only to pay 15,000*l.* Moreover, he said that having spent 40,000*l.* under one of the most eminent engineers of the day—a man who was regarded as such—the ratepayers had a right to expect that their town should be satisfactory sanitarily. But he believed that instead of this the state of the town was the cause of much anxiety, and they could not pass a manhole there without meeting a great stench. If he were speaking correctly, by applying his system to Llandudno they would have saved 1000*l.* a-year after the works were concluded, and they would have sanitary results which would give no anxiety. The only question was, "Was he correct?" Until the thing was applied to Llandudno many people would not believe him, but they knew perfectly well that if the ejector they had seen that morning was in Llandudno, Liverpool, Chester, Southport, or any other place, the effect of it would be exactly the same.

Then again, in regard to Southport. He was told that a sum of 200,000*l.* had been spent there. Was the state of the town satisfactory now? He had no hesitation in saying that it was not. And why? Because the gravitating law would not operate successfully under the given conditions—it would not operate successfully unless they gave the sewage a proper velocity. Without velocity they had stagnation, and they knew the result. If they had spent 200,000*l.* in Southport he had no hesitation in saying that his system would have been more applicable and cheaper. One point he had failed to call their attention to, and that was in regard to the discharge of sewage into the sea. Under the gravitating system it could only operate when the tide was low, and the power the sewage possessed of making a discharge was owing to the perpendicular height cast over a distance, and when this was spread over a long distance it was impotent to do duty. But when it did make a vomit, it was a most foul and offensive vomit, and it had not time to discharge fully before the tide came back again, and back also came the vomit. He was a great advocate for sewage irrigation, but if they would insist on ejecting this sewage into the sea then what an advantage it would be to have it ejected into the sea when the tide was in. He considered this a very important point. If they would allow him, there was one thing he should like to mention. Sewage irrigation had not had fair play in the country, and until the separate system was adopted it would not. He was aware that gentlemen of eminence differed as to whether it was desirable to separate the rainfall or not, particularly in large towns. But let engineers reflect upon the system hitherto in operation. They had the rainfall, sewage, and manufacturer's waste all passing into one culvert, and they expected a sewage farmer to succeed under these circumstances! Invariably it was the case that where the gravitating principle was in operation the sewage went to the lowest points, and then it became perfectly unmanageable. Mr. Donaldson addressed the Sanitary Institute of Great Britain upon this matter, and his paper was full of good sound sense. The principle existing appeared to be to find out what was the smallest area they could use to take off the largest quantity of sewage. That was the plan which had hitherto been adopted. Now if the converse of that had been the policy it would have been more reasonable. It should have been, What is the largest quantity of land to which you can apply the smallest amount of sewage? Had this been the case then sewage would have been looked upon as a more valuable property. Until they could separate these two things, water and sewage, and apply the latter to the largest quantity of land, they would get nothing but annoyance and pooh-poohing of sewage farms. Moreover, sewage farms had been difficult to obtain, because the moment the land was wanted the landlord increased the rent. If the sewage could be sent fresh to any number of outfalls instead of one, these difficulties would be overcome, and by his system they could have as many outfalls as they liked. Under these circumstances they would get the minimum quantity and maximum manurial value. In reference to the pulsometer he pointed out that they could not put one of these pumps where they could put an ejector. If they did put it in such a position they could not convey steam to it and apply it to the sewage. Moreover with the pulsometer they would need someone to attend to it, but here they had a self-acting thing, one which could fill and empty itself without anyone being near it.

The CHAIRMAN asked Mr. Shone if in his calculations he had capitalised the pumping.

Mr. SHONE replied that he had. What he had said he did not mean offensively to any engineer. They had probed him as to costs and he could only tell them by comparisons. He had gone into the case of Llandudno, and the cost was of so much importance that one need not be too particular in speaking of individual cases. The sewers cost so much. He capitalised that. He would put down his system and then capitalise that; then he would capitalise the working expenses, and the difference should be 15,000*l.* to 40,000*l.* and the saving of a matter of 1000*l.* a-year. Lieurner's system dealt with fæcal matter and urine simply, his system dealt with all kinds of English sewage. His system was unlike Lieurner's, because it was suitable to English populations, which Lieurner's was not. Everyone who had visited Lieurner's system and then his were converts to his pneumatic system.

The CHAIRMAN said he thought they might assume that the pumping expenditure was included as a capitalised sum.

Mr. SHONE: That is so.

Lieut.-Colonel JONES then made a few remarks. He began by thanking them for the compliment they had paid to Wrexham in fixing it as their place of meeting, to see Mr. Shone's most important novelty in sewerage. The subject had been pretty fully discussed, but they perhaps would allow him, having observed it from the first, to say something about it. He had watched this experiment with great attention, and he thought the application to it of compressed air operated against it for some time, owing to ideas existing of the old mode of applying this motor, not only from the mechanical defects of the air-compressors hitherto in use, but from the fact that when compressed air was brought to the place of work it always required an executive engine which introduced a third friction and thus added to the expense. In Mr. Shone's case the air was the "transmitting" power rather than the "motive" power; and instead of being applied, as in rock drills, &c., to work a piston, it acted as its own piston directly upon the liquid. As a homely illustration, every time they blew their nose they put into force exactly Mr. Shone's system for getting rid of what he may call the sewage of the head. It gravitated into the cavities of the nostrils, by contracting the air-passages they drove it out. So the whole thing was a very simple adaptation of a very common action. In regard to his farm, he had been grinding at it for seven years, not as a labour of love as some had suggested, but because he had to get his living as well as others. He believed, however, that time had justified his anticipations, that with an average of seasons there was a fair profit for the farmer's capital, and repayment for his time and trouble in dealing with sewage if he had it delivered to the highest part of his farm. However hard it may be to convince Town Councils, it was nevertheless their duty to get rid of what they made foul. A farmer, who took a sewage farm, must know what he had to deal with, and it could not be expected that he could deal with an unlimited quantity of sewage diluted by rain-water. In taking this farm he made a stipulation that none but necessary alterations should be made. He took 84 acres from the Local Board, but since then he had added 20 acres more. The soil was fairly suitable, a sandy loam lying on a free subsoil. It was troublesome for artificial drainage, but possessed a good natural drainage, and what drainage he had had to make was in isolated spots, he needed no regular system of pipes at regular intervals. The amount of sewage for which the tanks were calculated amounted to about 20,000 gallons per hour, say some 500,000 gallons in twenty-four hours. He could never have more than that quantity, because "storm-water overflows" carried off the surplus; but in dry weather he had measured down to 300,000 gallons. When there was a large rainfall of course a lot of water and sewage went into the brook, which was a wild one, and readily carried the matter away. During the seven years he had been there only one season had been tolerably dry. He was sure that had he only sewage proper he should have very superior crops and less trouble, but having a fixed maximum, governed by "overflows," he was not of course burdened with what he could not deal with. He did not think it was unreasonable for anyone to ask for fixed data. He believed the application of sewage to land was the best thing to do. In regard to the difficulties of the separate system in large towns he did not think, if the scavenger's work was done well, that the rainfall would be so bad as not to be fit to go into the nearest brook, and it must certainly be purer than the mixture of sewage and rain-water issuing from "overflows."

Mr. THORBURN moved, "That the best thanks of the Meeting be given to the Mayor of Wrexham and Lieut.-Colonel Jones for the kind manner in which they had treated them, and for giving the explanation of the sewage system, and the management of the sewage farm." He also proposed that this motion be entered on the minutes.

This was seconded, and carried unanimously.

The Secretary (Mr. Vawser) moved a vote of thanks to the Mayor for the use of the Town Hall.

Mr. Dunscombe seconded, and the motion was also carried unanimously.

The Mayor and Lieut.-Colonel Jones having responded, a vote of thanks were passed to the Chairman and Secretary, and the Meeting concluded.

The examination of Mr. Shone's apparatus and the sewage farm occupied the whole time, and it was found impossible to visit the Westminster Collieries as originally proposed.

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